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Microwaves & RF

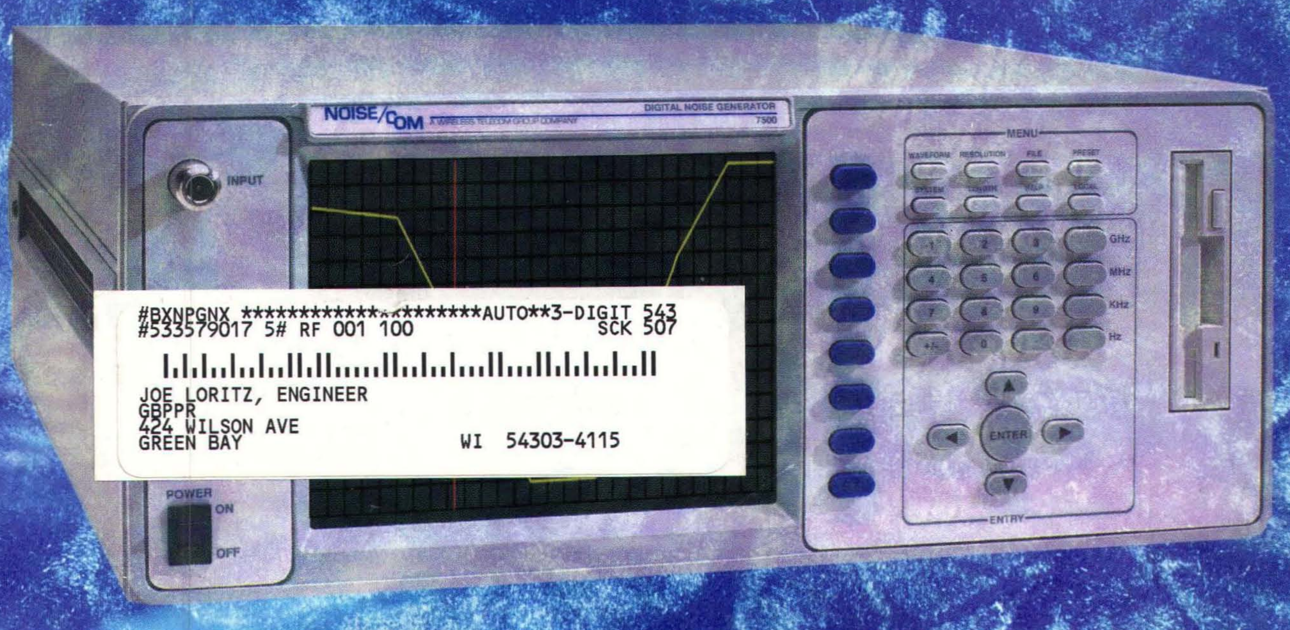
News
Surveying the latest high-power devices

Design Feature
PA power tunes with linear control

Product Technology
Mere +3 VDC controls MEMS SPDT switch

Instrument Tests GPS Noise Immunity

Amplifiers & Oscillators Issue



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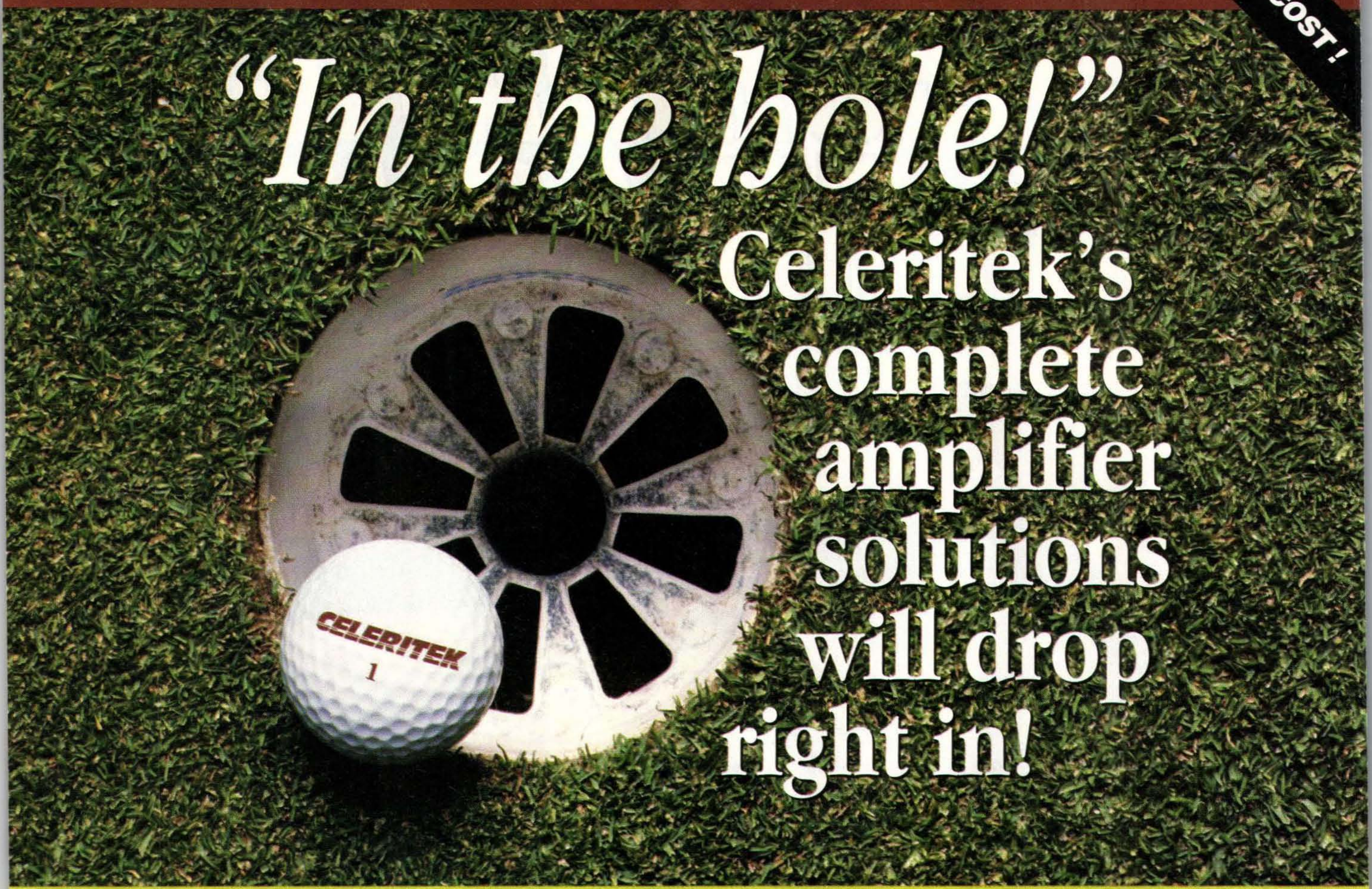
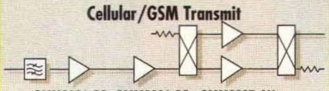
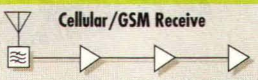


Cellular/GSM Transmit



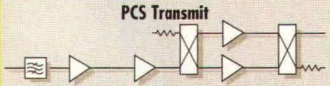
CMM6001-SC CMM6004-SC CMM6027-AH
CMM6004-SC CMM6025-SC CFK2062-P1
CMM0336-AK CFK2162-P1
CMM0335-AK CFH2162-P1

Cellular/GSM Receive



CFB0301 CMM6001-SC CMM6004-SC
CFB0303 CMM6004-SC CMM6025-SC
CFK0301 CMM0335-AK CMM6027-SC
CFS0301 CFK2061-P1
CFS0303 CFK2162-P1
CFH2162-P1

PCS Transmit



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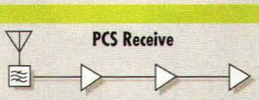
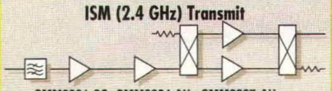
CMM1333-AK CFK2162-P3
CMM1335-AK CFH2162-P3

PCS Receive



CFB0301 CMM6004-SC CMM6004-SC
CFB0303 CMM6001-SC CMM6025-SC
CFK0301 CMM6027-SC
CFS0301 CFK2061-P3
CFS0303 CFK2162-P3
CFH2162-P3

ISM (2.4 GHz) Transmit

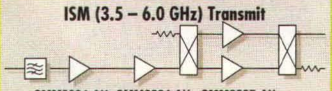


CMM6001-SC CMM6004-AH CMM6027-AH
CMM6004-SC CMM2321-AK CFH2162-P5
CFK2062-P5
CFK2162-P5

ISM (2.4 GHz) Receive

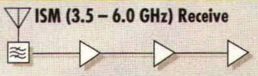
CFB0301 CMM6001-SC CMM6004-SC
CFB0303 CMM6004-SC CMM6025-SC
CFK0301 CMM6027-SC
CFS0301 CFK2061-P5
CFS0303 CFK2162-P5
CFH2162-P5

ISM (3.5 – 6.0 GHz) Transmit



CMM6004-AH CMM6004-AH CMM6027-AH
CMM3566-LC CMM6025-AH

ISM (3.5 – 6.0 GHz) Receive



CFB0301 CMM6004-AH CMM6004-AH
CFB0303 CMM6025-AH
CMM6027-AH

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CMM6001-SC	60 to 3000 MHz	20.5	38	2.4	12.0	5	75
CMM6002-SC	50 to 860 MHz	20.5	40	3.3	16.0	5	150
CMM6003-SC	50 to 870 MHz	20.5	40	3.0	16.0	5	150
CMM6004-SC	250 to 3000 MHz	23.5	41	2.1	14.5	5	150
CMM6004-AH	250 to 6000 MHz	23.5	41	2.0	14.5	5	150
CMM6025-SC	250 to 3000 MHz	26.5	42	2.3	14.0	5	370
CMM6025-AH	250 to 6000 MHz	27.0	42	2.3	14.3	5	370
CMM6027-AH	250 to 6000 MHz	29.0	42	3.0	13.0	5	650

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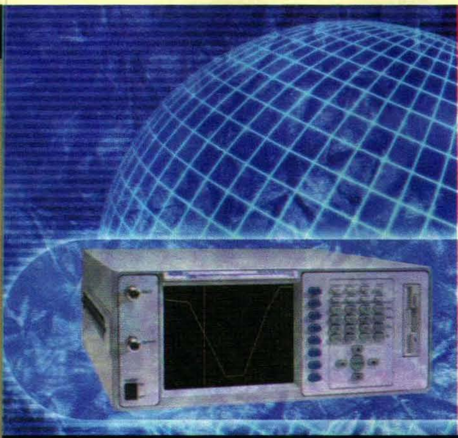

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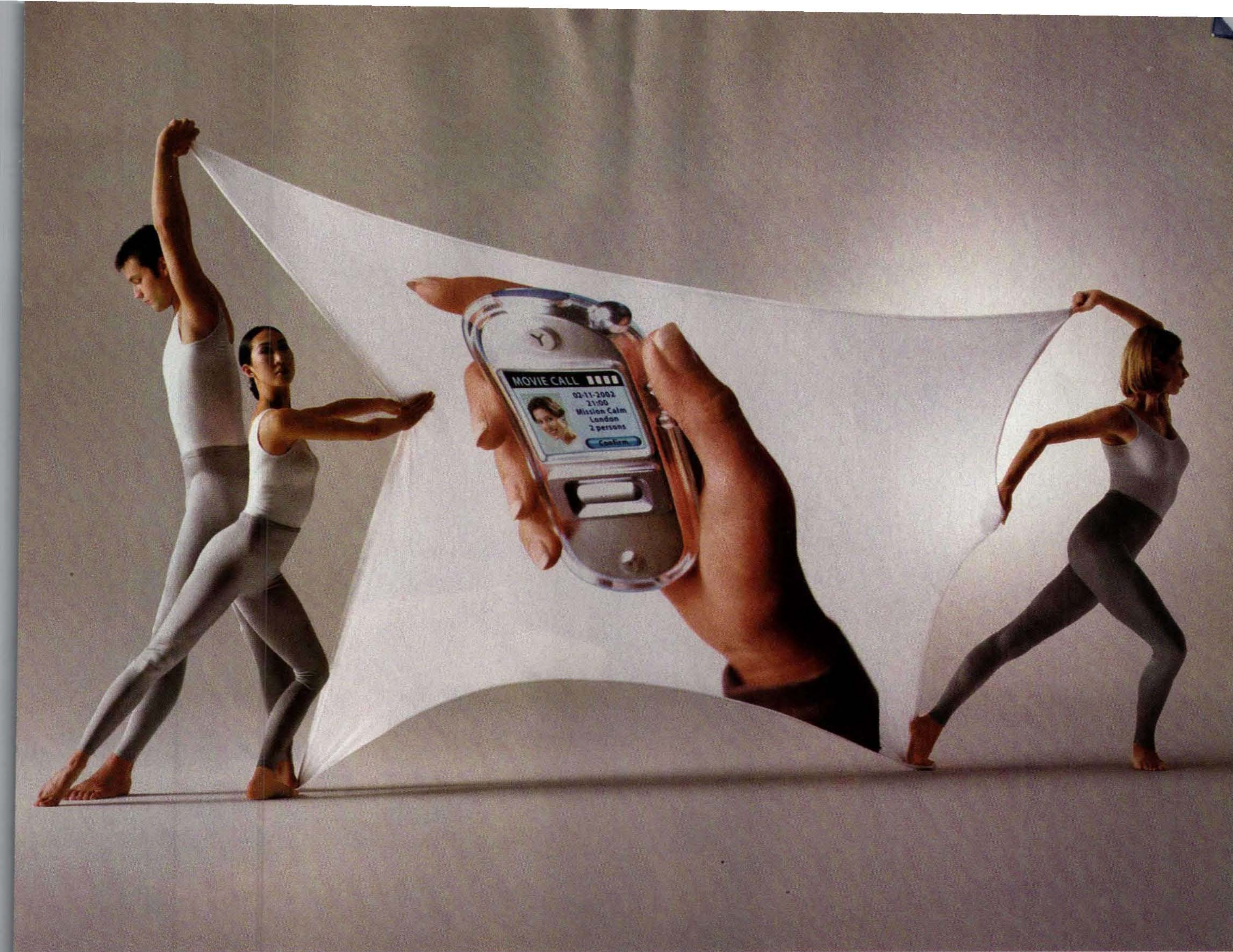
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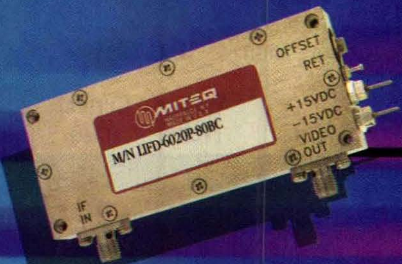
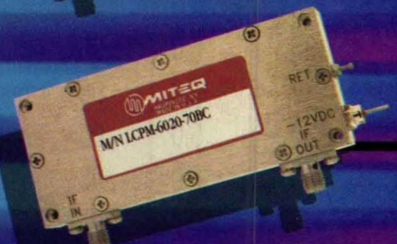
SUCCESSIVE DETECTION LOGARITHMIC AMPLIFIERS



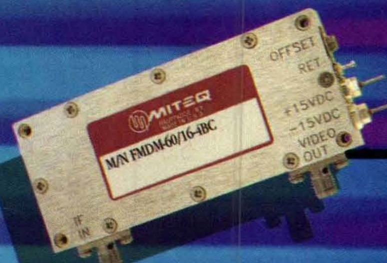
MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dBm, Min.)	LINEARITY (dB, Max.)	RISE TIME (ns, Max.)	LOGGING SLOPE INTO 93 OHMS (mV/dB, Typ.)
LIFD-3010P-80BC	30	-80 to 0	±0.5	100	25
LIFD-6020P-80BC	60	-80 to 0	±0.5	50	25
LIFD-7030P-80BC	70	-80 to 0	±0.5	30	25
LIFD-16040-80BC	160	-80 to 0	±1.0	30	25
LIFD-300100-70BC	300	-70 to 0	±1.0	20	15

CONSTANT PHASE LIMITING AMPLIFIERS



MODEL NUMBER	CENTER FREQUENCY (MHz)	DYNAMIC RANGE (dB, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)	PHASE VARIATION (Max.)
LCPM-3010-70BC	30	-70 to 0	10	±0.5	±3°
LCPM-6020-70BC	60	-70 to 0	10	±0.5	±3°
LCPM-7030-70AC	70	-65 to 5	10	±0.5	±5°
LCPM-16040-70BC	160	-65 to 5	10	±1.0	±3°

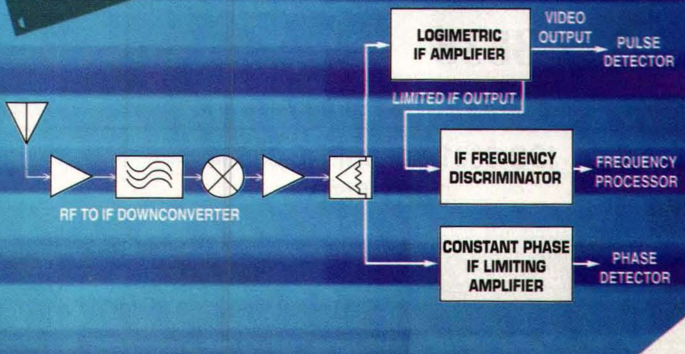
FREQUENCY DISCRIMINATORS



MODEL NUMBER	CENTER FREQUENCY (MHz)	LINEAR BANDWIDTH (MHz, Min.)	SENSITIVITY (mV/MHz, Typ.)	LINEARITY (%, Max.)	RISE TIME (ns, Max.)
FMDM-30/6-3BC	30	6	1000	±3	120
FMDM-60/16-4BC	60	16	250	±3	90
FMDM-70/36-10AC	70	36	50	±2	50
FMDM-160/35-15BC	160	35	100	±2	30
FMDM-160/50-15AC	160	50	40	±2	25
FMDM-750/150-20BC	750	150	20	±3	20
FMDM-1000/300-50AC	1000	300	10	±5	7

AUTOMATIC GAIN CONTROL LINEAR AMPLIFIERS

MODEL NUMBER	CENTER FREQUENCY (MHz)	BANDWIDTH (-3 dB) (MHz, Min.)	DYNAMIC RANGE (dBm, Min.)	OUTPUT POWER (dBm, Min.)	POWER VARIATION (dB, Max.)
AGC-7-10.7/4AC	10.7	4	-70 to 0	10	±0.5
AGC-7-21.4/10AC	21.4	10	-70 to 0	10	±0.5
AGC-5-70/30AC	70	30	-50 to 0	-4	±0.5
AGC-7-160/30AC	160	30	-70 to 0	8	±1.5
AGC-7-300/400AC	300	400	-65 to 0	3	±1.0



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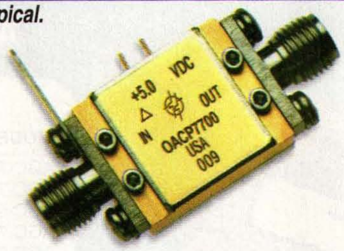
Oscillator with internal MMIC amplifier available in SMTO-8 or CougarPak™.								
OAS5100	4300-5100	0-15	13.0/2.0	-84/-108	50-85	-22	5.0	94
OAS6100	4700-6100	0-15	10.0/2.0	-80/-102	70-150	-25	5.0	95
OAS6500	5000-6500	0-15	13.0/2.0	-80/-102	80-160	-25	5.0	94
OAS6700	5300-6700	0-15	10.0/2.0	-75/-100	80-180	-30	5.0	95
OAS7700	5700-7700	0-15	10.0/2.0	-75/-100	70-250	-30	5.0	95
OAS8600	6500-8600	0-15	10.0/2.0	-70/-95	90-250	-30	5.0	95
OAS8900	6900-8900	0-15	10.0/2.0	-70/-95	100-270	-30	5.0	95
Oscillator only available in SMTO-8 or CougarPak™.								
OS5100	4300-5100	0-15	0/1.5	-85/-108	50-85	-12	5.0	25
OS6100	4700-6100	0-15	0/2.0	-80/-102	70-150	-12	5.0	26
OS6500	5000-6500	0-15	1.0/2.0	-80/-102	80-160	-17	5.0	26
OS6700	5400-6700	0-15	0/2.0	-75/-100	80-180	-17	5.0	25
OS7700	5700-7700	0-15	2.0/2.0	-75/-100	70-250	-17	5.0	25
OS8600	6500-8600	0-15	1.0/2.0	-70/-95	90-250	-20	5.0	25
OS8900	6900-8900	0-15	1.0/2.0	-70/-95	100-270	-25	5.0	24

Specifications are typical.



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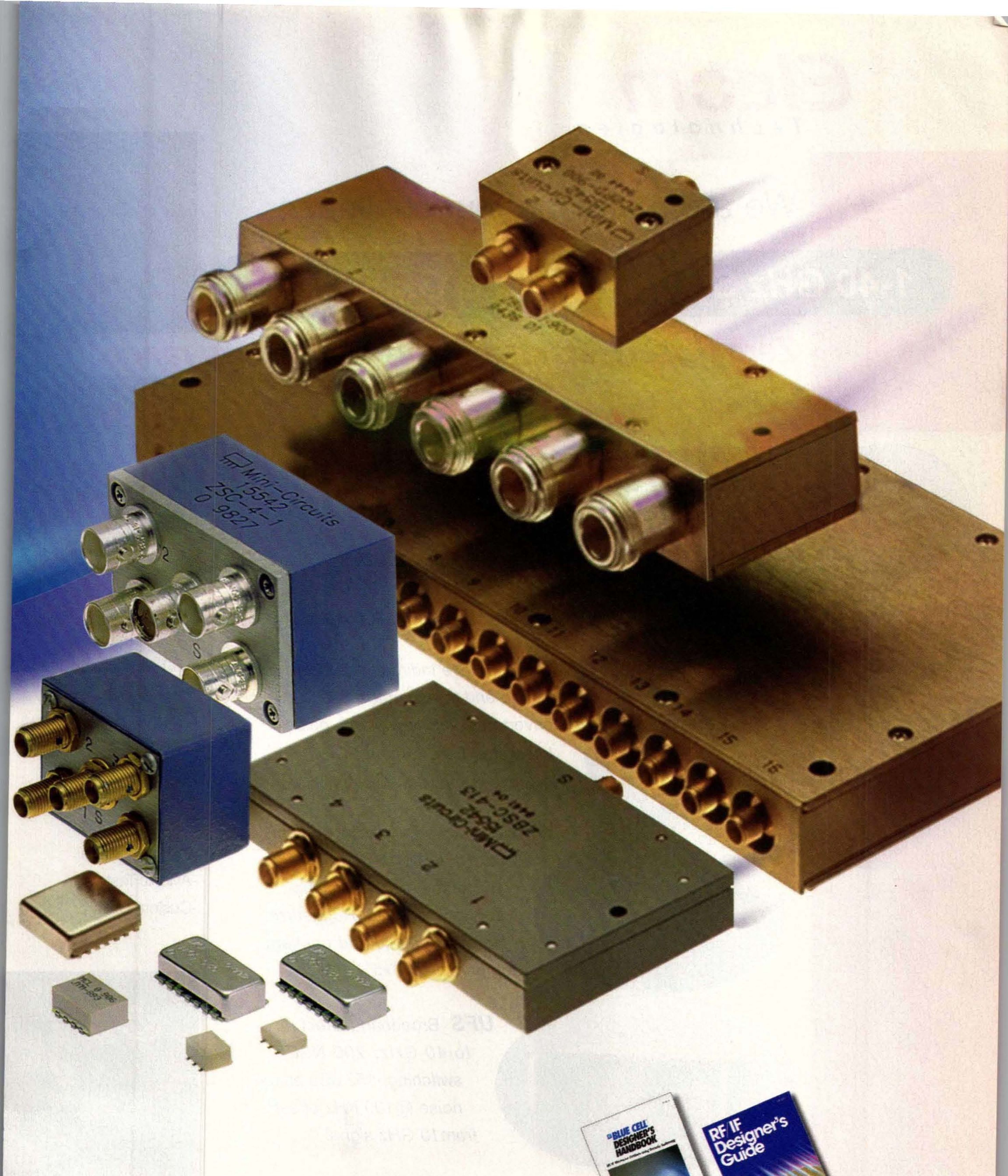
More On Military

▸▸IN PERUSING YOUR magazine over the last several months, I've noticed several editorial mentions and advertisements for a Military Electronics Show. Obviously, the timing is right for such an event, given the present situation in Iraq. If one also considers the weakness of current commercial markets in wireless communications [perhaps with the exception of wireless local-area networks (WLANs)], then it is easy to see the need for an event targeting military electronics.

I have read the various pieces on the show, and have gone to the website for the Military Electronics Show (www.mes2003.com), but am still unsure about the target audience. Is this a show that attempts the cover military electronics technology from the system level, i.e., with technical descriptions of such things as electronic-warfare (EW) systems and radar systems? Or is it more like a military version of the Microwave Theory & Techniques (MTT-S) show held recently this year in Philadelphia? I was not in attendance at the two earlier editions of this event, nor have I heard much about the attendance or the technical programs of those shows, so I would be interested in learning more about the history and philosophy of the Military Electronics Show. I do feel that the site you have chosen for the event, in the Baltimore Convention Center, is ideally located in terms of drawing attendees from key government organizations. But I would like to know more about the intended audience.

William Meredith

Editor's Note: Thank you for your interest in the Military Electronics Show. Now entering its third year, all in Baltimore, the basic idea of the show is to bring together designers of military electronic components, test equipment, circuits, software, and sometimes systems with the folks who have requirements for what they design. This philosophy is applied to the recruitment of exhibitors, and it also helps guide the selection of technical presentations for the conference. These presentations tend to be of a practical (rather than theoretical) nature and are intended to provide continuing education on electronic technologies (hopefully) of interest to engineers working on products for military customers, whether the customer be at the module, subsystem, or full-up system level. In its first two years, the show drew a representative sampling of the government agencies you mention, along with engineering managers from many key defense contractors. For more information on the Military Electronics Show, I invite you to visit our website at www.mes2003.com or drop me an e-mail at jbrowne@penton.com.


Mini-Circuits
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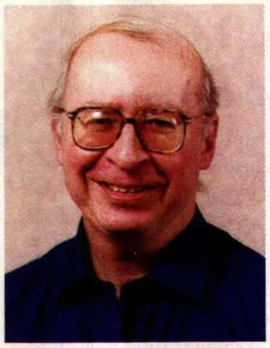
RF/IF Designer's Guide

from the editor

Assembling This Summer's Reading



SUMMER MONTHS USUALLY SPELL RELIEF for overworked employees (in the form of vacations), and loss of productivity for employers (juggling work schedules because of those vacations). Some companies make the best of this conflict by subsidizing vacations for their staffs: a case in point is oscillator/synthesizer supplier Micro Lambda Wireless (Fremont, CA) which will ship its full crew and their families to Hawaii this summer as a way of saying thanks.

A well-written book is often a welcome companion for the quiet hours of a summer vacation.

For most employees, vacation is a time to escape their working routines and take a break from the folks they see most of the year. This "free" time is ripe with opportunities to finish that back deck, or fix those broken windows, or any number of little tasks around the home. It is also a chance to read a few books and increase one's skills and knowledge. For that reason, this month's column features a brief look at some of the better technical books released during the past year—books that can enrich an RF engineer's practical knowledge, and reward an astute employer with improved productivity upon that return from vacation.

For example, a technology that is rapidly gaining ground among RF designers is well covered in *RF MEMS: Theory, Design, and Technology* by Gabriel Rebeiz (Wiley, www.wiley.com, see June, p. 74 for a review). The text includes mechanical and electromagnetic (EM) modeling, design of antennas, filters, phase shifters, switches, oscillators, and inductors, and several case studies in MEMS design.

For those seeking more on passive components, *Integrated Passive Component Technology* edited by Richard Ulrich and Leonard Schaper (Wiley) does a nice job of explaining how to optimize the performance of capacitors, inductors, and resistors on monolithic and other substrates. On the active side, *Modern Microwave Transistors: Theory, Design, and Performance* by Frank Schwierz and Juin Liou (Wiley) is an excellent roundup of all major transistor types, from older silicon bipolars and MOSFETs to emerging silicon-carbide (SiC) and gallium-nitride (GaN) MESFETs. At the system level, *Microwave Radio Links: From Theory to Design* by Carlos Salema (Wiley) packs about 28 years of teaching experience on telecommunications into just under 500 pages.

Two respected names in RF software, Rowan Gilmore and Les Besser, have assembled *Practical RF Circuit Design for Modern Wireless System* (Vol. 2, Artech House, www.artechhouse.com), with a focus on active devices, amplifiers, mixers, and oscillators. Another name synonymous with software modeling, Steve Maas, has revised his classic text, *Nonlinear Microwave and RF Circuits* (Artech House).

Certainly, a well-written book is often a welcome companion for the quiet hours of a summer vacation. It's also a way of letting that darned employer know that all that time off wasn't totally unproductive.

Jack Browne

Publisher/Editor

Microwaves & RF

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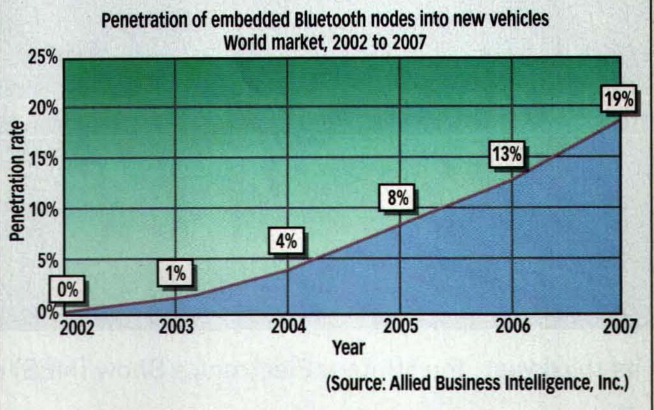
News items from the communications arena.

Telephony Is Only The Beginning For Bluetooth In The Vehicle

OYSTER BAY, NY—Nearly 20 percent of all new vehicles worldwide will contain embedded Bluetooth hardware by 2007 **(see figure)**, according to the findings of "Automotive Wireless Networks: Examining The Proliferation of WLAN and PAN Technologies Into The Automotive Platform," a report from Allied Business Intelligence, Inc. (ABI). Future Bluetooth-based automotive applications are poised to deliver new opportunities to all facets of the industry, from silicon vendors and hardware manufacturers to automakers and gasoline retailers.



Daimler Chrysler's UConnect hands-free car kit will serve as Bluetooth's US automotive introduction. In Europe, certain Audi, BMW, Peugeot, and Saab models currently offer Bluetooth hands-free car kits as options.

Bluetooth silicon costs run approximately $6, making the technology extremely attractive to automakers, and ABI predicts that costs will continue to fall. Besides cost, the key automotive driver is Bluetooth's proliferation into an increasing number of mobile handsets. Bluetooth car kits are relatively simple and inexpensive to install.

While the first wave of Bluetooth devices in the vehicle will center around telephony, newer applications will soon follow. These include remote vehicle diagnostics, lower-cost telematics services, advanced automotive safety systems, vehicle-to-vehicle communications, and remote audio and video downloads into the vehicle, among others.

Ansoft Supports Virginia Tech Future Energy Electronics Center

PITTSBURGH, PA—Ansoft Corp. and Virginia Tech's Future Energy Electronics Center (FEEC) have teamed to develop new, efficient power-electronics technology and an innovative graduate curriculum based on Ansoft's electronic-design software for physics-based system simulation.

"Ansoft's tools are essential for power-electronics system simulation and are very easy for students to learn," says Dr. Jih-Sheng (Jason) Lai, director of the FEEC. "The software provides the advanced capabilities needed for forward-thinking research. The ability to simulate power-electronic circuits, digital/analog controls, and electromechanical components within a single integrated environment is extremely powerful and accurate."

The FEEC's current research focuses on several alternative energy power-generation applications, including fuel-cell-powered vehicles, DC/DC and DC/AC power conversions, and electromagnetic interference (EMI). As part of their coursework, graduate students at FEEC must complete selected electronic-design projects related to these technologies using several Ansoft EM and Signal Integrity products, including SIMPLORER®, Maxwell®, PExprt™, RMxprt™, Spicelink™, AnsoftLinks™, and Optimetrics™.

"Alternative energy research and development is a natural area for Ansoft's unique physics-based system-simulation projects," comments Mark Ravenstahl, Ansoft's product marketing manager. "Many of our automotive, aerospace, and telecommunications customers are intensely researching alternative energy strategies."

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"China's major telecom operators will undertake substantial upgrades to prepare for the 2008 Olympics."

Final Public Demonstration Of CHAUFFEUR 2 Takes Place

MILTON KEYNES, ENGLAND—The final public demonstration of the CHAUFFEUR 2 systems has taken place at IVESCO's test track facility in Balocco, Italy. High-profile guests from all areas of the automotive industry attended the successful presentation and practical systems demonstrations.

During the demonstrations, guests were invited to experience CHAUFFEUR 2 system functions by riding in the trucks of DaimlerChrysler AG, IVECO S.p.A., and RenaultVi-Volvo, which all use Wavelength Solutions' telematics wireless equipment. System functions demonstrated included electronic-lane keeping, smart-distance keeping, wireless towbar, and multiple vehicle wireless platoon convoy for road traffic and transportation.

The CHAUFFEUR 2 collaboration also included other leading automotive-component suppliers such as Robert Bosch, ZF, and Wabco.

As part of the CHAUFFEUR 2 program, Wavelength Solutions researched and developed prototype license-exempt 5.8-GHz RF/microwave direct-sequence-spread-spectrum (DSSS) radio transceivers and robust vehicle-to-vehicle communications protocols for all of the leading truck manufacturers involved in the program.

Wavelength Solutions' telematics equipment included a Controller Area Network (CAN) bus communications interface for connection directly to the Vehicle Controller (VC) unit. This allowed data to be communicated from the VC on one vehicle to the VC on a different vehicle using the wireless telematics equipment.

The Wireless Telematics equipment and 5.8-GHz DSSS radio transceiver unit, used for establishing the vehicle-to-vehicle radio communications, are suitable for any secure, reliable, high-data-rate (up to 11 Mb/s on-air) transfer applications in today's business, which include automotive, industrial, consumer, medical, and security environments.

Telecom Infrastructure Upgrade To Happen For Beijing's Olympics

AUSTIN, TX—As part of the sweeping modernization projects due to take place for the 2008 Summer Olympic Games, Beijing Communications Corp., the local operating company serving China's national capital, will invest $6.64 billion US over the next five years to extend and upgrade its network. This is a fraction of the $37 billion US planned for expenditures to host the 2008 Olympics. These figures are reported in a market-research report, *Beijing's 2008 Olympics—Business Opportunities in Modernizing Beijing's Telecom Networks*, from Communications Consulting Associates of Austin, TX.

CCA reports that the Beijing Communications Corp.'s $6.64 billion US investment, which represents approximately $0.9 billion US per year, will support several objectives, including: adding capacity for an additional 3.4 million fixed network voice lines; replacing linear optical network connections with rings and upgrade existing SDH rings to higher bit rates; and developing IP-based video transport networking capable of supporting HDTV.

Beijing Communications Corp. is not alone in planning infrastructure upgrades. According to the CCA report, Beijing Mobile and other industry participants will also upgrade their networks to not only support traffic associated with the Olympic Games, but also for greater market penetration, new or improved services, and greater international connectivity. Beijing Mobile, for example, plans to roll out 3G networks that will support video, sport statistics, smart-card functions, and other services.

These plans for telecom investment come on the heels of several recent and extensive changes in China's telecom industry. Last year, for example, China's Ministry of Information and Industry split the nationwide monopoly service provider into two large regional groups. Also in 2002, China's accession to the World Trade Organization changed the competitive landscape for telecom-equipment and service companies. At the same time that they are adjusting to the telecom industry's new regulatory and competitive structure, China's major operators will undertake substantial upgrades to prepare for the 2008 Olympics.

CCA's 2008 Olympic report describes the rapid changes being planned, the partnerships being formed, the complex workings of the government organizations and telecom companies involved, and the multibillion-dollar expenditures specific to information infrastructure and communications networks planned for the Beijing region. The report includes more than 60 pages of analysis and information on Beijing and Olympic infrastructure details.

Bluetooth Headset Debuts At Bluetooth World Congress

AMSTERDAM, THE NETHERLANDS—Gennum, a supplier of integrated circuits (ICs) for the hearing-instrument industry demonstrated a Bluetooth™ headset at the Bluetooth World Congress, which took place on June 17 to 19 at the Amsterdam RAI.

Gennum has developed a Bluetooth headset powered by a specialized audio IC technology and the GR2312 GenBlue™ module. The module, based on CSR's BlueCore2 chip technology, provides full 8-Mb Flash and access to all of the inputs and outputs available on the BlueCore2 chip. It combines High Density Interconnect technology with Thin-Film RF circuitry to produce a small Bluetooth module.

"The module provides full 8-Mb Flash and access to all of the inputs and outputs available on the BlueCore2 chip."

The Bluetooth headset incorporates FRONTWAVE™, Gennum's multi-memory signal processor, creating a directional response and improving the quality of conversations in noisy environments. FRONTWAVE technology also eliminates the need for a microphone boom.

Kudos

LEDGEWOOD, NJ—Bomar RF Interconnect Products, Inc. has named Richardson Electronics as "Distributor of the Year" in the Broadcast Products Group for 2002. The award is based on Richardson's year-over-year sales growth, together with their continued commitment to superior service and support for Bomar's traditional and proprietary interconnect products for RF transmission.

In 2001, Bomar signed an exclusive Global Supplier Agreement (GSA) with Richardson to provide a broader range of RF connector solutions to the customer, as well as provide an accelerated route to market for Bomar's broadcast products worldwide. Distributors that had been considered for the honor included companies headquartered throughout the US.

The presentation took place at Richardson's regional office in Ronkonkoma, NY on May 1.

CEDAR RAPIDS, IA—Rockwell Collins has been selected by Egypt Air to provide avionics and in-flight entertainment (IFE) for five new Airbus A320-200 aircraft. Aircraft deliveries are scheduled to begin this year.

The avionics package selected by Egypt Air includes Rockwell Collins' suite of data-link communications, navigation, and surveillance sensors, including the GLU-920 multimode receiver (MMR). The Collins WXR-2100 Multiscan Weather Radar was also selected and will be installed once certification is complete.

VISTA, CA—Palomar Technologies, a manufacturer of automated assembly systems, announced that it has received the 2002 Inspire Award from the League of American Communications Professionals (LACP) for its electronic employee newsletter, the Bonders News Network.

The LACP supports and recognizes excellence in the practice of professional communications. More than 300 entries were submitted for the LACP's annual employee newsletter/website competition. Through several hundred hours of judging, LACP identified winners within peer-level competition classes. Scores were derived according to a proprietary judging system developed by LACP, which assigns point values to various criteria of an entry.

AUSTIN, TX—Wireless Valley announced that its president, Roger Skidmore, has received his doctorate degree in electrical engineering from the University of Virginia Tech, Blacksburg.

Dr. Skidmore's dissertation, entitled "A Comprehensive Method and System for the Design and Deployment of Wireless Data Networks," introduces novel techniques related to radio coverage and prediction, site-specific wireless planning, and wireless data-network management, performance, and analysis. Many of these breakthroughs are encapsulated within Wireless Valley's products and intellectual-property portfolio. Over three dozen patents have been awarded or are pending, based in part on Dr. Skidmore's research, which was funded exclusively by Wireless Valley under a corporate fellowship program to encourage entrepreneurial engineering students to pursue advanced degrees while working full time at the then-fledgling start-up. The Wireless Valley Bradley Industrial Fellowship fund allowed several premier Virginia Tech students to pursue graduate degrees while working for Wireless Valley.

IRVINE, CA—The Orange County Council of AeA celebrated the tenth anniversary of its annual High-Tech Awards and honored Gordon Taylor as the 2003 Outstanding Executive—Private Company.

Gordon Taylor has been with Racal for over 40 years and has led what is now Racal Instruments for 38 of those years. MRF

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Part Number	Bandwidth (MHz)	Package (mm)
855735	.25	24.6x9.0
855736	.5	24.6x9.0
855737	1	24.6x9.0
855738	1.5	24.6x9.0
855739	2	19.0x6.5
855740	2.5	19.0x6.5
855741	3	19.0x6.5
855742	3.5	15.3x6.5
855743	4	19.0x6.5
855744	4.5	19.0x6.5
855745	5.5	19.0x6.5

140 MHz High-Selectivity Filters

Part Number	Bandwidth (MHz)	Package (mm)
856062	.75	19.0x6.5
856063	1.5	19.0x6.5
856064	2	19.0x6.5
856065	3	19.0x6.5
856066	6	13.3x6.5
856067	7	13.3x6.5
856068	8	13.3x6.5
856069	10	13.3x6.5
856070	14	13.3x6.5
856071	16	13.3x6.5
856019	28	9.0x7.0
856072	32	9.0x7.0
856073	44	9.0x7.0
856074	56	9.0x7.0
856020	64	9.0x7.0

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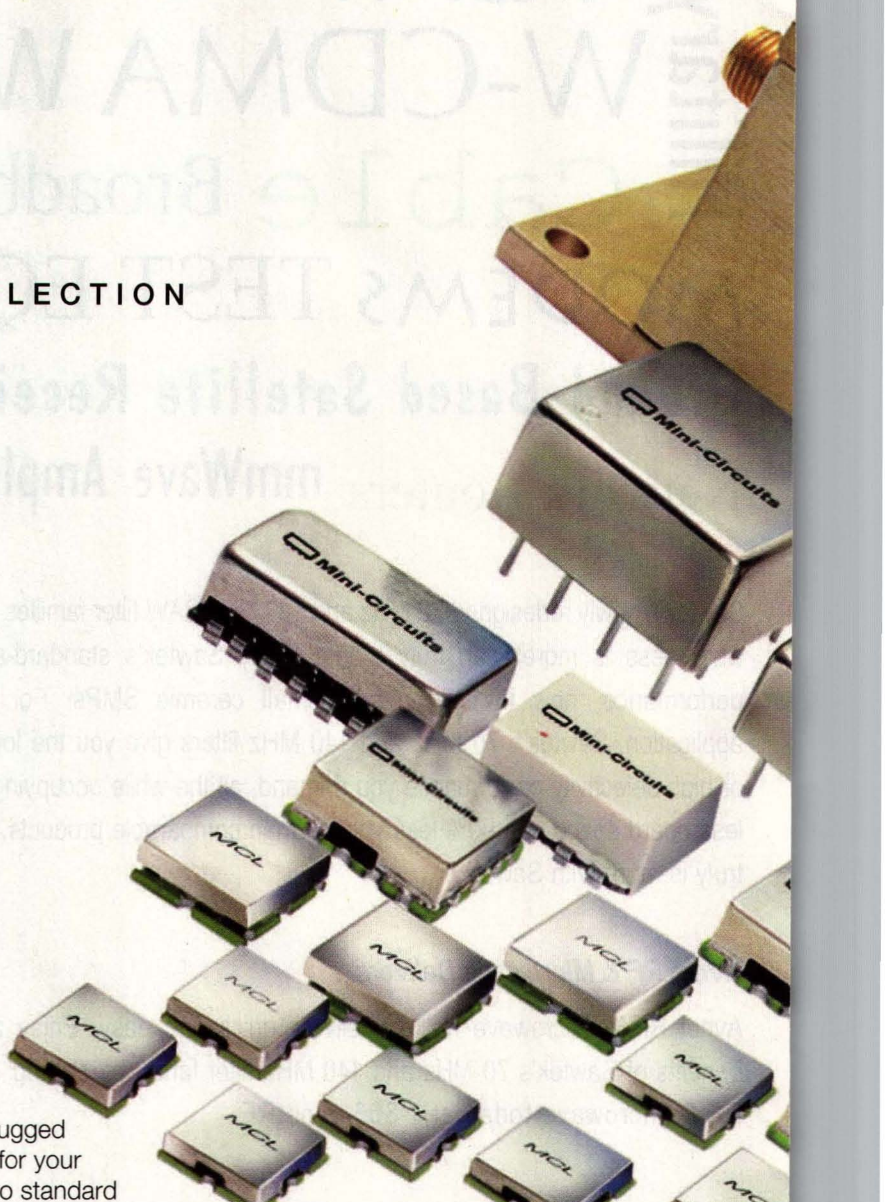

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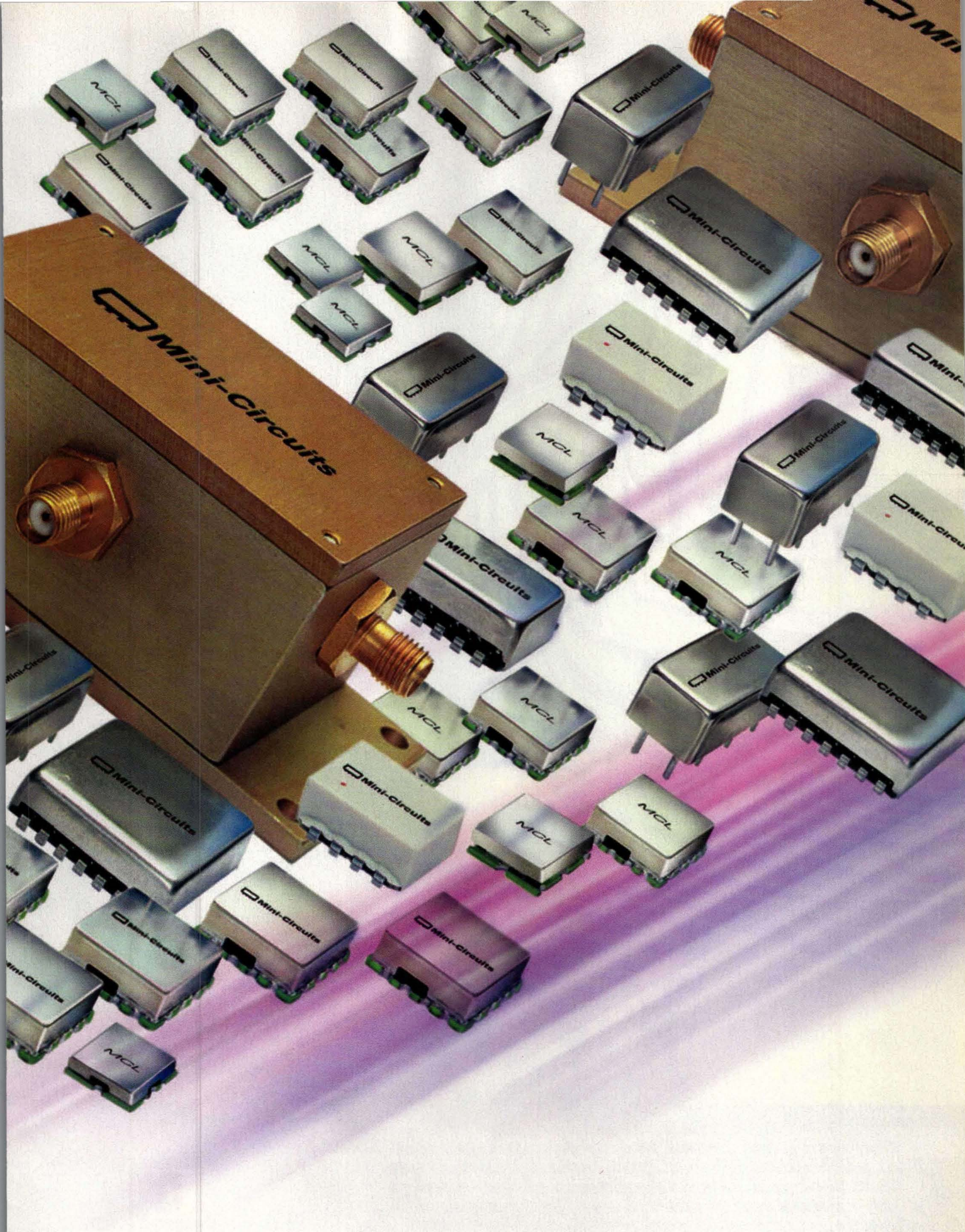

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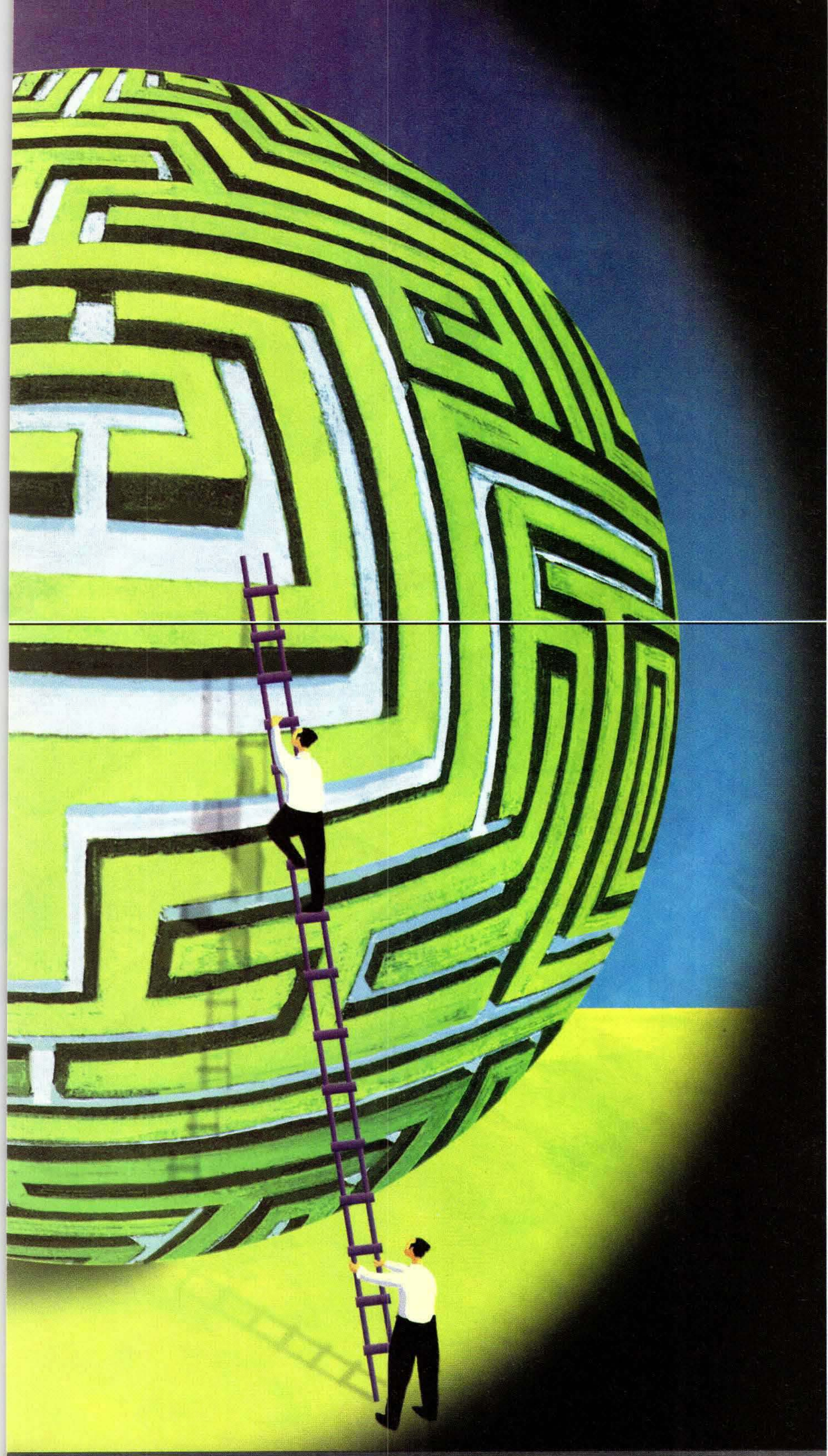

NEWS

Tracking Advances In Solid-State Power

Suppliers of high-power transistors continue to improve on processing and packaging as new devices show improvements in power density, linearity, and efficiency.

JACK BROWNE
Publisher/Editor

Transistor developers continue to push for higher power levels from a single die or package, but not to the exclusion of other performance parameters. Especially for commercial communications applications, device designers now emphasize improved linearity and efficiency so that amplifier designers can create smaller and lighter units for mobile radios and compact base stations. What follows is a sampling of recent developments in RF and microwave power transistors.

Several device announcements were made at the recent IEEE Microwave Theory & Techniques Symposium (MTT-S, June 10-12, Philadelphia, PA), including the launch of several high-voltage high-frequency (HF) MOSFET devices by Advanced Power Technology RF (www.advancedpower.com). Both are nominally intended for HF amplifiers and RF plasma generators at frequencies from 1.5 to 30 MHz. The ARF465A/B, for example, dissipates as much as 250 W power and generates as much as 125 W output power when operating with a +300-VDC supply. The larger model ARF1505 dissipates as much as 1500 W power and generates output levels to 750 W CW from a +300-VDC supply. The rugged design features a power density of 700 W/in.[2]

At the show, the company also announced two new lateral-diffused MOS (LDMOS) transistors for pulsed avionics and radar applications, the 110-W peak-power model 1011LD110 and the 200-W peak-power model 1011LD200. The +32-VDC transistors offer gain levels of 13 and 12 dB, respectively, over the 1030-to-1090-MHz Identify Friend or Foe (IFF) avionics band.

Advanced Semiconductor (www.advancedsemiconductor.com) features a wide range of CW and pulsed RF power transistors, including a wide range for DME/TACAN avionics applications from 1025 to 1150 MHz. Several devices with internal input and output matching networks offer output-power levels of 250 W and more, including the 400-W model AVD400 and the 500-W model AVD500. These +50-VDC parts both feature minimum efficiency of 40 percent with respective gains of 6.5 and 5.6 dB.

Philips Semiconductors (www.semiconductors.philips.com) is a long-time supplier of high-power transistors, and features several RF bipolar models for TACAN and JTIDS avionics applications (roughly 960 to 1215 MHz), including the models MX0912B251Y and the MX0912B351Y. The former features 275 W of pulsed output power while the latter produces 375 W of pulsed output power. Both devices yield 7.5-dB gain at 45-percent efficiency.

Another veteran device supplier, M/A-

COM (Tyco Electronics), offers both power bipolar and MOSFET devices for a wide range of applications, including the model PH1090-700B bipolar transistor for pulsed avionics applications. The gold-metalized, ceramic-packaged device delivers 700 W of pulsed (32-µs pulses at a 2-percent duty cycle) output power from 1030 to 1090 MHz. The +65-VDC device features 7.5-dB power gain with 50-percent collector efficiency.

Additional high-power silicon transistor suppliers include Polyfet RF Devices (www.polyfet.com) and Point Nine Technologies (www.pointnine.com). Polyfet's model SR401 is a +28-VDC push-pull transistor capable of 300 W output power at 175 MHz. The transistor features 13 dB gain and 55-percent efficiency.

Point Nine's model C203, one of the company's line of TetraFET devices, is usable to 1 GHz. The silicon DMOS device employs gold metalization to gain 100 W output power from a +28-VDC supply. The rugged transistor achieves 10 dB gain with 40-percent drain efficiency. Another of the company's TetraFETs, the model D1027, provides 200 W output power at frequencies from DC to 300 MHz. The +28-VDC transistor generates 17 dB gain with 50-percent efficiency.

"Plastic" was the key word at the Motorola (www.motorola.com) booth during the show, as the company unveiled several plastic-packaged MOSFETs, including the MRF5S9101MR1 which is designed for applications to 1 GHz. The device yields 105 W 1-dB-compression CW output power at 960 MHz with 16.5 dB gain and 56-percent efficiency. Capable of operating at +26 or +28 VDC, the device is well suited for GSM base-station applications, with error-vector-magnitude (EVM) performance of 3 percent.

STMicroelectronics (www.us.st.com) is developing a new family of +100-VDC high-power VHF/UHF MOSFETs. The new process utilizes enhanced raised-gate technology for feedback capacitance reduction and optimized deep body doping to improve load mismatch tolerance. Proprietary techniques result in increased breakdown voltages and reduced parasitic capacitance, with a 6-dB increase in power gain compared to standard +50-VDC devices. The transistors employ thermally enhanced nonpedestal packaging and will be available in 150-W (model SD3931-10) and 300-W (model SD3933) single-ended configurations as well as a dual 300-W (model SD3932) configuration. The devices are currently being evaluated in a variety of applications, including plasma generators and magnetic-resonance-imaging (MRI) systems.

At somewhat higher frequencies, Mitsubishi Semiconductors (www.mitsubishichips.com) announced the availability of a pair of internally matched GaAs FET devices for Ku-band very-small-aperture-terminal (VSAT) satellite-communications applications. The

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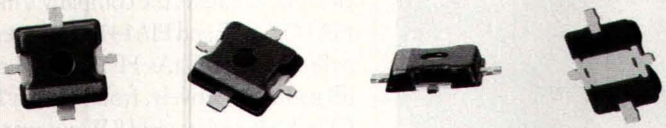

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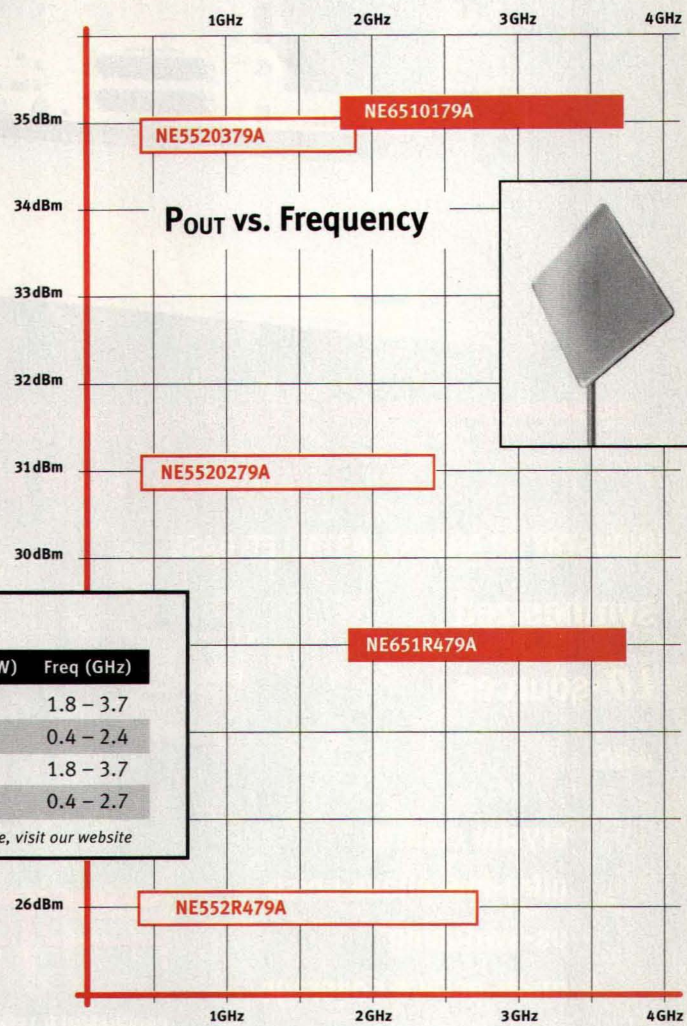

Typical Performance @ 2.3 GHz, V_{DD} = 5V

Part Number	Type	P_{1dB} (dBm)	G_L (dB)	R_{TH} (°C/W)	Freq (GHz)
NE6510179A	GaAs	35	11	5	1.8 – 3.7
NE5520279A	LDMOS	31	10	7	0.4 – 2.4
NE651R479A	GaAs	29	12	12	1.8 – 3.7
NE552R479A	LDMOS	26	11	10	0.4 – 2.7

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model MGFK41A4045 delivers 12 W output power in the 14.0-to-4.5-GHz VSAT band while the model MGFK44A4045 produces 24 W output power from 14.0 to 14.5 GHz.

Also serving satellite-communications applications, the TIM5964-90SL GaAs FET from Toshiba America Electronic Components (www.taec.toshiba.com) promises 90 W (+49.5 dBm) output power from 5.9 to 6.4 GHz. The internally matched C-band transistor helps amplifier designers reduce the number of parts in their designs by replacing several lower-power devices. The transistor features 7 dB typical gain with 30-percent typical power-added efficiency (PAE) and a third-order intermodulation distortion (IMD) of typically –40 dBc.

The use of internal impedance matching allows Excelics Semiconductor (www.excelics.com) to provide as much as 8 W output power at VSAT frequencies. For example, the company's models EIA1415A-8P and EIA1415B-8P are internally matched GaAs FETs with 6 and 8 dB gain, respectively, from 14.0 to 15.35 GHz; both devices yield 8 W output power over that range. The devices are rated for PAE of 20 percent and third-order intercept point of +46 dBm.

Another supplier with an extensive lineup of internally matched devices, Fujitsu Compound Semiconductor (wwwfcsi.fujitsu.com), offers numerous C-band devices include the model FLM3742-25F. Designed for +10-VDC supplies, the transistor achieves +44.5-dBm output power with 10.5 dB typical gain and 41-percent efficiency from 3.7 to 4.2 GHz.

California Eastern Laboratories (www.cel.com) offers the NE650103M power GaAs FET for L- and S-band applications through 2.7 GHz. Ideal for PCS and wireless-local-loop (WLL) applications, the device operates from a +10-VDC supply with 10 W (+40 dBm) output power and 42-percent typical efficiency. The power gain is typically 11 dB at 2.7 GHz.

Several power-transistor processes that have yet to gain wide acceptance among amplifier designers include those based on silicon-carbide (SiC) and gallium-nitride (GaN) substrates. For the former, Cree (www.cree.com) has offered several versions of a 10-W device for several years. Now available as model CRF-24010, the device is usable to 2.7 GHz with at least 10 W output power and 15 dB gain.

Because of the high-power potential of materials such as SiC and GaN, large defense contractors such as BAE Systems (www.baesystems.com) and Northrop Grumman Corp. (www.northgrum.com) have made major investments in device development. More details will be available at the upcoming Third Annual Military Electronics Show (www.mes2003.com, Baltimore, MD, September 16-17, 2003). MRF

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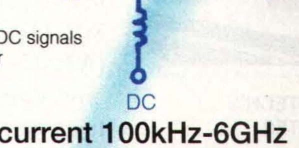

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▲ZFBT-4R2G	10-4200	0.15	0.6	0.6	32	40	50	1.13:1	59.95
▲ZFBT-6G	10-6000	0.15	0.6	1.0	32	40	30	1.13:1	79.95
▲ZFBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	50	1.13:1	79.95
▲ZFBT-6GW	0.1-6000	0.15	0.6	1.0	25	40	30	1.13:1	89.95
▲ZFBT-4R2G-FT	10-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	59.95
▲ZFBT-6G-FT	10-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-4R2GW-FT	0.1-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-6GW-FT	0.1-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	89.95
★ZNBT-60-1W	2.5-6000	0.2	0.6	1.6	75	45	35	1.35:1	82.95
■PBTC-1G	10-1000	0.15	0.3	0.3	27	33	30	1.10:1	25.95
■PBTC-3G	10-3000	0.15	0.3	1.0	27	30	35	1.60:1	35.95
■PBTC-1GW	0.1-1000	0.15	0.3	0.3	25	33	30	1.10:1	35.95
■PBTC-3GW	0.1-3000	0.15	0.3	1.0	25	30	35	1.60:1	46.95
•JEBT-4R2G	10-4200	0.15	0.6	0.6	32	40	40	-	39.95
•JEBT-6G	10-6000	0.15	0.7	1.3	32	40	40	-	59.95
•JEBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	40	-	59.95
•JEBT-6GW	0.1-6000	0.15	0.7	1.3	25	40	30	-	69.95

L = Low Range M = Mid Range U = Upper Range

NOTE: Isolation dB applies to DC to (RF) and DC to (RF+DC) ports.

▲SMA Models, FT Models Have Feedthrough Terminal ★Type N, BNC Female at DC

■Pin Models •Surface Mount Models

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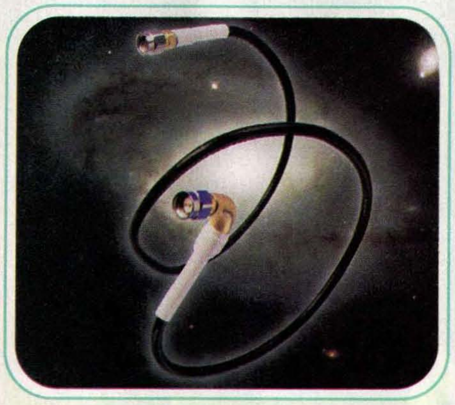
Lightweight Cables Handle Space Use

LIGHTWEIGHT 0.19-IN.-DIAMETER microwave cable assemblies have been developed for space-flight applications from DC to 18 GHz. About 20-percent lighter than the company's conventional 0.19-in. cables, the space-flight cables consist of a TEFZEL outer jacket and mechanical shield wrapped around an electrical shield and outer conductor which is in turn wrapped around a low-dielectric-constant core and large-diameter inner conductor cable. The 2U cable is just 44 g per m and is rated for operating temperatures from –55 to +125°C.

W.L. Gore & Associates, 402 Vieve's Way, Elkton, MD 21922; (800) 445-4673, (302) 292-5100, Internet: www.gore.com/electronics.

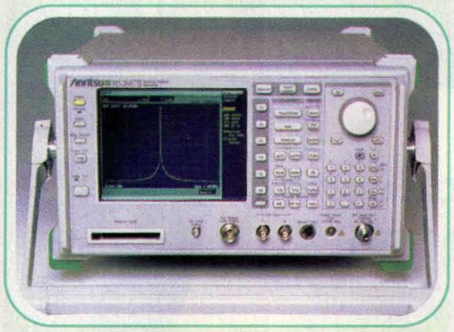


W.L. GORE'S MICROWAVE CABLE ASSEMBLIES

Spectrum Analyzer Filters 20-MHz Bands

DESIGNED FOR INVESTIGATING wideband channels such as found in wideband code-division-multiple-access (WCDMA) systems, the MS2687B spectrum analyzer features low phase noise and a 20-MHz resolution bandwidth across a center frequency tuning range of 9 kHz to 30 GHz. The spectrum analyzer, which features a dynamic range as wide as 156 dB, features an average noise level of less than 136 dBm/Hz at microwave frequencies. The instrument's advanced digital-signal-processing (DSP) capabilities and 64-MHz analog-to-digital converter support accurate burst power measurements on wideband signals. A multiple waveform display function allows two waveforms to be superimposed and simultaneously displayed for analysis in the frequency and time domains. P&A: $36,400; 6 to 8 wks.

Anritsu Co., 1155 East Collins Blvd., Richardson, TX 75081; (972) 644-1777, FAX: (972) 644-3416, Internet: www.ansitsu.com.



ANRITSU'S MS2687B SPECTRUM ANALYZER

Turnkey Tester Probes Differential Circuits

A TURNKEY SOLUTION has been developed for characterization of multiport or differential linear devices and circuits to 8.5 GHz. Consisting of dual high-performance characterization probes, a series of dedicated impedance standard substrates (ISSs), the ENA Wafer Cal calibration software, an ENA series RF network analyzer from Agilent Technologies (Santa Rosa, CA), and a flexible probing system, the system allows accurate analysis of differential devices and integrated circuits (ICs) commonly used in wireless communications systems. The ENA Wafer Cal software quickly guides an operator through the normally tedious task of setting up and calibrating the test system, using advanced algorithms that require only four of the possible six through paths to be measured during calibration.

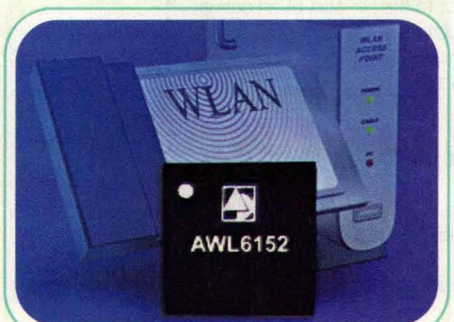
Cascade Microtech, Inc., 2430 N.W. 206th St., Beaverton, OR 97006; (800) 550-3279, (503) 601-1000, Internet: www.cascademicrotech.com.

CASCADE MICROTECH'S TURNKEY TESTER

Power-Amplifier Module Boosts 2.4-GHz WLANs

DESIGNED FOR NEAR "plug-and-play" use in 2.4-GHz IEEE 802.11b and 802.11g wireless local-area-network (WLAN) systems, the model AWL6162 power-amplifier (PA) module requires few external components for biasing (three bypass capacitors for noise filtering) and none for impedance matching. Supplied in a surface-mount package measuring 4 × 4 × 1 mm, the module typically delivers average output power of +22 dBm with 2.5-percent error vector magnitude (EVM) when running with IEEE 802.11g format signals at 54 Mb/s and 2.4 to 2.5 GHz. It can operate with either a +3.3 or +5-VDC supply.

ANADIGICS, Inc., 141 Mount Bethel Rd., Warren, NJ 07059; (908) 668-5000, FAX: (908) 668-5132, Internet: www.anadigics.com.



ANADIGICS' AWL6162 POWER-AMPLIFIER MODULE

Elcoteq Forges Strategic Initiative

ELCOTEQ NETWORK CORP., the largest European electronics-manufacturing-services (EMS) company for the communications technology industry, announced that Elcoteq Americas has begun a new strategic initiative. Led by the management team of Dr. Douglas Brenner, president, Dr. Michael Hegedus, director of Elcoteq's supply-chain management and sourcing, and Bill Coker, director of sales and marketing, Elcoteq Americas is focusing its EMS efforts solely on communications technology customers and products throughout the Americas.

Elcoteq Americas is located in Irving, TX. The company hopes to provide American firms with end-to-end global service solutions from their low-cost manufacturing facility in Monterrey, Mexico, NPI Americas network, and facilities in Eastern Europe and China. Elcoteq provides a full range of services consisting of electrical and mechanical design and engineering, new product introduction (NPI), manufacturing, supply-chain management, SMT assembly and test, systems integration, product distribution, and after-market sales services for the entire lifecycle of its customers' products.

Product areas consist of terminal products and communications network equipment. Terminal products include mobile phones and smart accessories (e.g., Bluetooth), PDAs and wireless terminals including intelligent peripherals, and digital home communication products such as set-top boxes. The communications-network-equipment area serves OEM companies that produce various types of communication-infrastructure equipment and communications networks. These consist of mobile and broadband switches and base-station controllers, mobile base stations, antennas and antenna near products such as filters, power amplifiers (PAs), and tower-top amplifiers.

As part of the initiative, Elcoteq recently purchased NPRC of Dallas, TX, a new-product-introduction services company. Acquisition of NPRC initiated the implementation Elcoteq's strategy of locating NPI services close to customers. NPRC is now named Elcoteq, NPI Dallas. Elcoteq plans to continue purchasing NPI centers that are located near strategic customer locations. MRF

CONTRACTS

The Titan Corp.—Announced that the US Army's Program Manager for Tactical Radio Communications Systems has awarded Titan a $19.2 million contract to provide systems engineering, technical assistance, and acquisition assistance for the Army's family of tactical voice and data radios. These systems include the Single Channel Ground and Airborne Radio System (commonly known as SINCGARS), the Enhanced Position Location Reporting System, and the Joint Tactical Radio System (JTRS), the Army's newest transformational voice and data system.

EMS Technologies, Inc.—Signed a $1.25 million contract with NASA Dryden Flight Research Center to deliver a SATCOM antenna for Flight Demo 2 of NASA's Next Generation Launch Technology (NGLT) Space-Based Telemetry and Range Safety (STARS) project. As part of the NGLT, researchers are looking at technology that reduces the overall operational costs of supporting launches into space.

EMS Space & Technology/Atlanta will modify one of its advanced phased-array antenna designs to allow operation with NASA's Tracking & Data Relay Satellites (TDRS). NASA plans to test the antenna on an F-15B Research Testbed aircraft in mid 2004. The antenna, when installed, will enable NASA to maintain a telemetry link to vehicles from GEO satellites instead of ground stations.

Herley Industries, Inc.—Announced that its Herley New England facility has been awarded a $2.3 million contract from Textron Systems of Wilmington, MA. Herley will supply microwave hardware for their enhanced Sensor Fuzed Weapon ("SFW"), a air-to-surface smart munition. The performance period for this contract is one year, after which additional follow-on awards are expected.

The US Air Force inventory objective for the enhanced SFW is in excess of 2000 weapons. The SFW is capable of being deployed from an increasing number of aircraft, including A-10, B-1, B-2, F-15, F-16, and F-18.

IKE Micro—Has been awarded orders from three defense electronics companies for build-to-print manufacturing services. IKE has received a 6300-unit order for high-power amplifiers from M/A-COM's Aerospace and Defense Business Unit, a 600-unit order for logarithmic amplifiers from Signal Technology, and production orders for two amplifier subassemblies from BAE Systems IEWS group.

FRESH STARTS

RF Micro Devices, Inc. and Silicon Wave—Have agreed to enter into a strategic relationship for Bluetooth® solutions manufacturing and distribution.

Within the strategic relationship, Silicon Wave will grant manufacturing licenses to RF Micro Devices for their single-chip UltimateBlue™ 3000 radio processor and stand-alone CMOS Bluetooth radio modem solutions. RF Micro Devices will be responsible for the supply chain of Silicon Wave's CMOS Bluetooth solutions and will be the exclusive distribution channel for these products. RF Micro Devices has also acquired a minority interest in Silicon Wave by participating with other investors in Silicon Wave's current preferred stock equity financing.

Pulse—Has reached an agreement with Avnet, Inc., a technology marketing, distribution, and services company. In addition to Pulse's current line of products, Avnet will stock and distribute Pulse's full line of catalog and custom military and aerospace products. Products include MIL-STD-1553 transformers and data bus couplers, high-speed Fibre Channel, Gigabit Ethernet, and IEEE 1394B transceivers and transformers, active and passive delay lines, as well as power transformers. The agreement is in keeping with Pulse's strategy to supplement its direct sales force with authorized distributors and representatives.

CETECOM—Announced that an agreement has been reached with Agilent Technologies in order to guarantee a global support for CETECOM Test Systems.

CETECOM products will be maintained, calibrated, and repaired through Agilent's global network of service centers worldwide.

The customer service teams at CETECOM and Agilent will work together to satisfy requirements for automatic diagnostics, fast repair, and calibration of the Bluetooth, GSM/GPRS, and WCDMA test equipment used in BITE and MiNT Testers.

Link Microtek—Has been appointed as exclusive representative for TriQuint Semiconductor, Inc. in the UK and Ireland.

Keithley Instruments, Inc.—Has entered into a collaborative agreement with Modelithics, Inc. The two companies will share information and work together to create more efficient software modeling techniques used to design advanced RF semiconductor devices.

The two companies will combine resources to create advanced methods for using I-V and C-V data for more efficient modeling and circuit design.

Rohde & Schwarz—Opened an Internet shop at www.shop.rohde-schwarz.com. From the website, customers can select and order T&M equipment by e-commerce. For the time being, the service is only available in Europe.

Sprague-Goodman Electronics, Inc.—Appointed three new sales representatives.

Southern California will be covered by Dura Sales of Southern California (Diamond Bar, CA); sales in Arizona, New Mexico, and El Paso, TX will be the responsibility of Saguaro Technical Sales, Inc. (Scottsdale, AZ); Midtec Associates (Lenexa, KS) will handle Kansas, Missouri, Iowa, Nebraska, and Southern Illinois. MRF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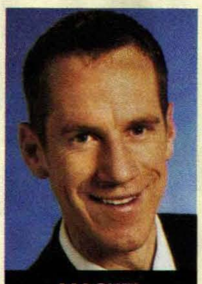
Rohde & Schwarz Names UK Managing Director


MACKEL

FRANK MACKEL has been appointed as managing director of Rohde & Schwarz UK Ltd. He is responsible for the company's sales and service activities in the UK and Ireland. Mackel previously headed the Rohde & Schwarz sales office for northern Germany.

Stealth Microwave—CAROLYN DETTREY to sales manager; formerly employed with California Eastern Laboratories.

Rogers Corp.—GARY CLINTON to product manager for the RO4000® high-frequency materials product line; formerly operations manager for the Rogers Flexible Circuit Materials Division. Also, COLLEEN MURPHY to market development manager for the liquid-crystalline-polymer (LCP) product line; formerly employed in business development and sales at North East Systems Associates (NESA).

Northstar Electronics, Inc.—S. ROBERT BLAIR to the board of directors; formerly chairman and CEO of the NOVA Corp. Group.

Schema—ANDREW SILBERSTEIN to COO; continues as president. Also, DAPHNA BAHAT to associate vice president of marketing; formerly vice president of marketing for Speedwise. In addition, TOM HAMMOND to vice president of sales for the Americas; formerly vice president of sales and marketing with Paratek Microwave, Inc.

Zarlink Semiconductor, Inc.—SCOTT MILLIGAN to CFO; formerly vice president for finance and administration with UUNet Canada (later WorldCom Canada).

OnRamp Communications Corp.—JESSIE MCCANN to graphic designer; formerly art director at the Weber Marketing Group.

Zyray Wireless—JOHN MAJOR to the board of directors; remains as president of MTSG.

Broadband Services, Inc.—ANTONIO DOMINGUEZ to vice president for national accounts; formerly vice president for sales and marketing for broadband access markets with Neptec Optical Solutions, Inc.

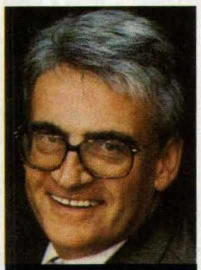
Recognition Source—GORDON SIBBALD to Northeast regional sales manager; formerly manager of sales and business development for the Integrated Security Systems Group in the Northeast for Simplex/Grinnell.

Microsemi Corp.—CHRISTINE (CHRIS) MCALLISTER to regional sales manager at the Microwave Products operation in Lowell, MA; formerly employed in a regional sales position at MCE/Metellics, and was responsible for Eastern USA and European markets.

American Beryilla Corp.—RICHARD LOGATTO to vice president for sales and marketing; formerly president of LoGatto, Inc., a sales and strategy consulting firm.

Zetex—PATRICK PENNEKAMP to distribution manager for the Americas; formerly corporate marketing manager for semiconductor products at Pioneer Standard Electronics.


PENNEKAMP


ALBARELLO

Thales Computers—ALAIN ALBARELLO to chairman and CEO; formerly director of the Inboard Technology Center.

California Micro Devices—DAVID L. WITTROCK to the board of directors; formerly vice president for finance and business affairs at Rioport, Inc. MRF

►SHORT COURSES

Indoor Networks: Principles & Practice of In-Building Wireless Engineering
August 7-8 (Miami, FL)
September 11-12 (San Francisco, CA)
For further information, contact:
Dr. Eric Reifsnider
(540) 818-2281
e-mail: training@wirelessvalley.com
Internet: www.wirelessvalley.com/Services/Training.asp

Antenna Measurement & Techniques Association (AMTA) 2003 Short Course: Selected Topics from Veteran AMTA Speakers
October 19-24 (Irvine, CA)
Hyatt Regency Hotel
For further information, contact:
John Demas
e-mail: jdemas@nearfield.com
Internet: www.amta2003.com

►MEETINGS

INTERTECH 2003
July 28-August 1 (Vancouver, BC, Canada)
Hyatt Regency Vancouver
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Columbus, OH 43229
(614) 797-2265, FAX: (614) 797-2264
e-mail: t-kane@insight.rr.com

2003 Prepaid Markets Expo
August 10-12 (New York, NY)
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(727) 399-2812
e-mail: expo@prepaid-telecom.com

Wescon North America
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Moscone Convention Center
Internet: www.wescon.com

2003 IEEE Symposium on Electromagnetic Compatibility
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Hynes Convention Center
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2003 IEEE EMC Symposium
c/o IEEE—Conference Management Services
445 Hoes Lane
Piscataway, NJ 08855
Internet: www.emc2003.org

PortablePower 2003
September 21-24 (San Francisco, CA)
Moscone Convention Center
For further information, contact:
Brooke Selby
IDG World Expo
(508) 424-4808
e-mail: brooke_selby@idg.com
Internet: www.idgworldexpo.com

ElectronicAmericas
October 6-10 (Sao Paulo, Brazil)
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To exhibit, contact:
Randi M. West
(312) 377-2650
Internet: www.munichtradefairs.com

CTIA Wireless I.T. & Entertainment 2003
October 21-23, 2003 (Las Vegas, NV)
Sands EXPO and CONVENTION, Venetain Hotel
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Internet: www.ctiashow.com

25th Annual IEEE GaAs IC Symposium
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For further information, contact:
IEEE
445 Hoes Lane
Piscataway, NJ 08855-1331
Internet: www.gaasic.org

Productronica 2003
November 11-14 (Munich, Germany)
New Munich Trade Fair Centre
To exhibit, contact:
Randi M. West
(312) 377-2650
Internet: www.munichtradefairs.com

The 36th Annual International Symposium on Microelectronics and Electronic Packaging
November 16-20 (Boston, MA)
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(202) 548-4001
e-mail: imaps@imaps.org
Internet: www.imaps2003.org

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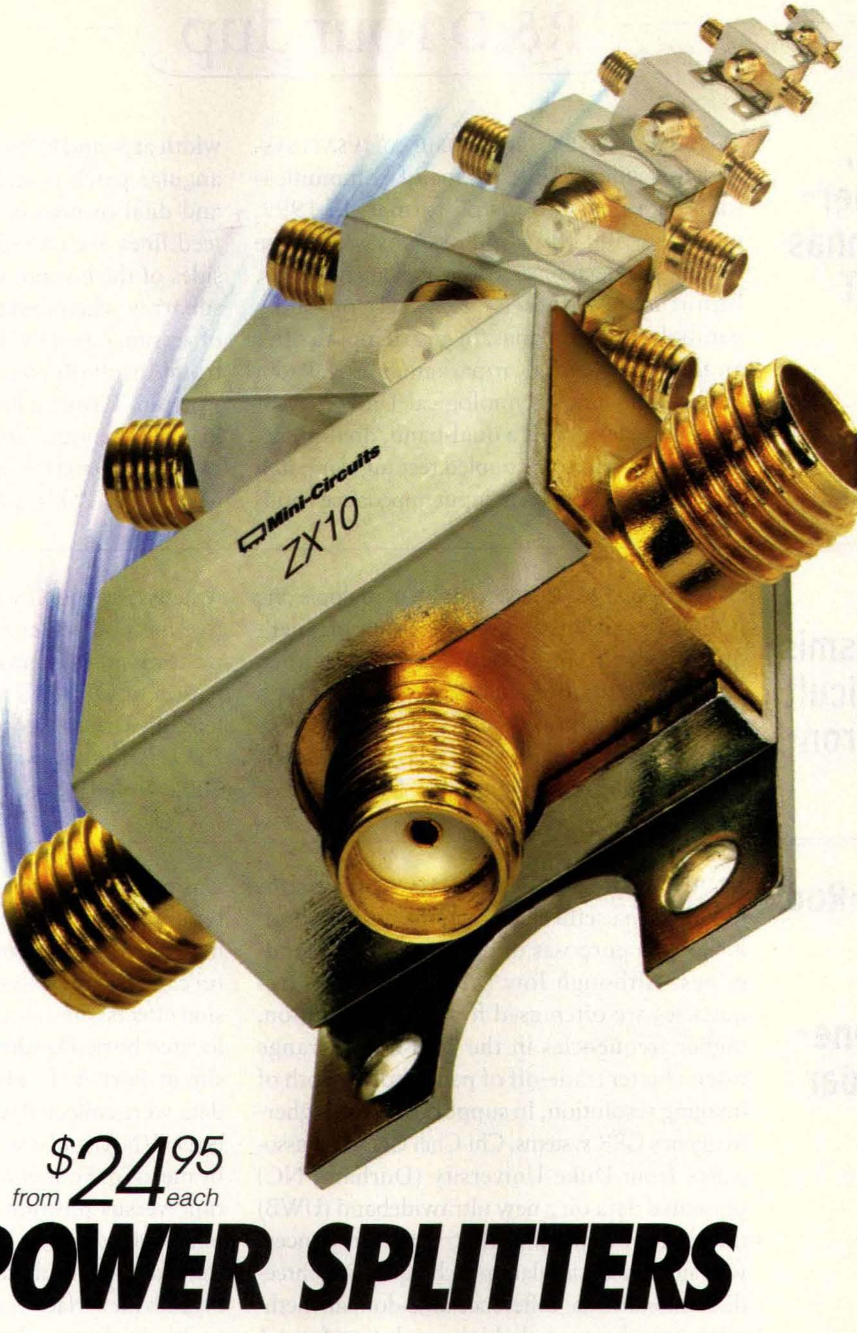
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Dual-Band, Shared-Aperture Antennas Serve VSAT Systems

VERY-SMALL-APERTURE-TERMINAL (VSAT) systems provide reliable means of communications in an easy-to-install format. In 1999, more than 500,000 VSAT systems were in use worldwide, for commercial and military networks. Unfortunately, these systems rely on bulky parabolic dish antennas. In an attempt to offer an alternative, N.C. Karmarkar and S.K. Padhi of the Nanyang Technological University of Singapore developed a dual-band, dual-polarized shared-aperture coupled rectangular patch antenna with 21-percent input impedance bandwidth at S- and C-bands. In their design, a rectangular patch is etched on the top substrate and dual orthogonal coupling apertures and feed lines are etched on the top and bottom sides of the bottom substrate. A four-element subarray when design designed with the help of version 6.0 of the Ensemble design software from Ansoft (Pittsburgh, PA). See "Very Small Aperture Terminal Broadband Shared-Aperture Planar Antennas," *International Journal of RF and Microwave Computer-Aided Engineering*, May 2003, Vol. 13, No. 3, p. 180.

Evaluating OFDM Transmission in Difficult Urban Environments

ORTHOGONAL FREQUENCY-DIVISION multiplexing (OFDM) transmission schemes support high-quality audio and video communications, although evaluating such schemes under high multiplath conditions can be nontrivial. Fortunately, George Pantos and fellow researchers from the National Technical University of Athens (Athens, Greece) demonstrate an effective method for evaluating different OFDM transmission systems. See "Performance Evaluation of OFDM Transmission Over a Challenging Urban Propagation Environment," *IEEE Transactions on Broadcasting*, March 2003, Vol. 49, No. 1, p. 87.

Dielectric-Rod Antenna Boosts Ground-Penetrating Radar Systems

GROUND-PENETRATING RADAR (GPR) systems have been a useful element in the military toolkit for the purposes of detecting buried landmines. Although low (kHz and MHz) frequencies are often used for deep penetration, higher frequencies in the 1-to-6-GHz range offer a better trade-off of penetration depth of imaging resolution. In support of these higher-frequency GPR systems, Chi-Chih Chen and associates from Duke University (Durham, NC) presented data on a new ultrawideband (UWB) dielectric-rod antenna that works in concert with numerical simulation techniques and three-dimensional finite-difference time-domain methods to yield extremely high resolution from 1 to 6 GHz.

The rod has a relative dielectric constant of 3, length of 60 cm, and width of 7.6 cm, and was modeled by means of the finite-difference time-domain (FDTD) method. After fabricating a prototype antenna and performing a careful calibration procedure (to minimize dispersion effects), measurements were performed to located buried landmines at a government test site at Fort A. P. Hill, VA. Swept-frequency data were collected with a vector network analyzer (VNA) and converted to the time domain by means of Fourier transform. After each scan, time-versus-position data are displayed to the operator, allowing the prototype to successfully locate cylindrical landmines buried 5 cm beneath the surface. See "A New Ultrawide-Bandwidth Dielectric-Rod Antenna for Ground-Penetrating Radar Applications," *IEEE Transactions on Antennas and Propagation*, March 2003, Vol. 51, No. 3, p. 371.

Analog Phase Shifter Handles 360-deg. Range at L-Band

BROADBAND ANALOG PHASE SHIFTERS provide much desired performance characteristics for both military radar and commercial communications systems. K. Liu and associates at the City University of Hong Kong (Kowloon, Hong Kong) developed a monolithic analog phase shifter capable of 360-deg. phase shifts over broad bandwidths at L-band frequencies. Fabricated using integrated-circuit and surface-mount component technologies, the phase shifter features less than ±2.5-dB linear deviation and less than 2-dB insertion loss from 1.2 to 2.0 GHz. The phase shifter features a dual-varactor scheme to achieve the full 360 deg. of control. A three-port microwave circulator was used to connect the input signal to the phase shifter, although the resulting microwave circuit is nonetheless compact, simple to design, and easy to produce in large quantities. For more information on the low-loss, broadband phase shifter, see "L-Band 360-deg. broad-bandwidth Monolithic Analog Phase Shifter," *Microwave and Optical Technology Letters*, February 5, 2003, Vol. 36, No. 3, p. 164.

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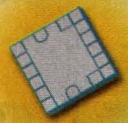

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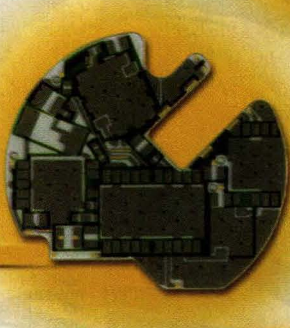

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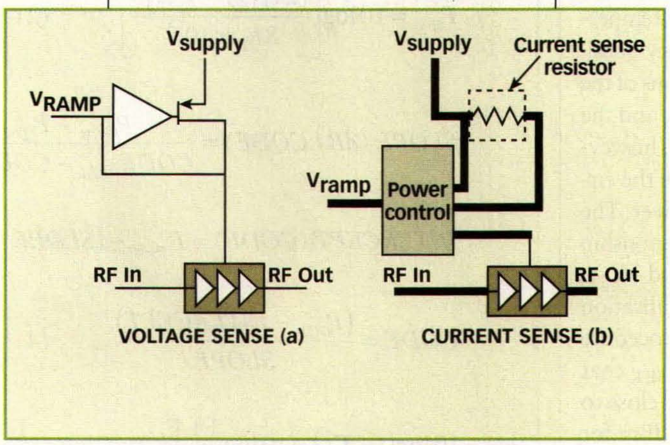
Linear Power Control Of GSM Amplifier Power

This technique of controlling PA module output power has advantages in dynamic range and accuracy compared to traditional current-sensing and voltage-sensing power-control methods.

Power-control methods for integrated Global System for Mobile Communications (GSM) power-amplifier (PA) modules are many. New methods include approaches based on sensing current and sensing voltage. But the best performance can be achieved with a linear-in-dB technique that provides an accurate and predictable method of controlling PA output power. In comparing these different approaches, the usual measures include output power and power-added efficiency (PAE). But other areas to consider include the PA's output-power stability as functions of temperature, frequency, load VSWR, and battery power; the dynamic range of the power-ramping function; the ease of calibration; trade-offs between PAE/battery current and output power; and the impact of the power-control circuitry on efficiency.

PHILIP SHER
Applications Engineer
Analog Devices, Inc., 804 Woburn St., Wilmington, MA 01887-3462; (781) 937-2815, FAX: (781) 937-1026, e-mail: phillip.sher@analog.com, Internet: www.analog.com.



1. These simple diagrams illustrate the voltage-sensing (a) and current-sensing (b) methods of PA output-power control.

The voltage-sensing **(Fig. 1a)** and current-sensing **(Fig. 1b)** methods are often used for PA output-power control. In the voltage-sensing method, a high-speed control loop is incorporated to regulate the collector voltage of the amplifier while the PA stages are held at a constant bias. By regulating the power, the stages are held in saturation across all power levels. As the required output power is decreased from full power down to 0 dBm, the collector voltage is also decreased. The current-sensing method senses the current supplied to the PA through the power supply. A complementary-metal-oxide-semiconductor (CMOS) controller controls the base voltage of the field-effect transistor (FET) with an error voltage generated by applying the ramp voltage, from the DAC, and the current measured to an error amplifier. These are both *indirect closed loop* methods as there is no direct measurement of the PA's output power.

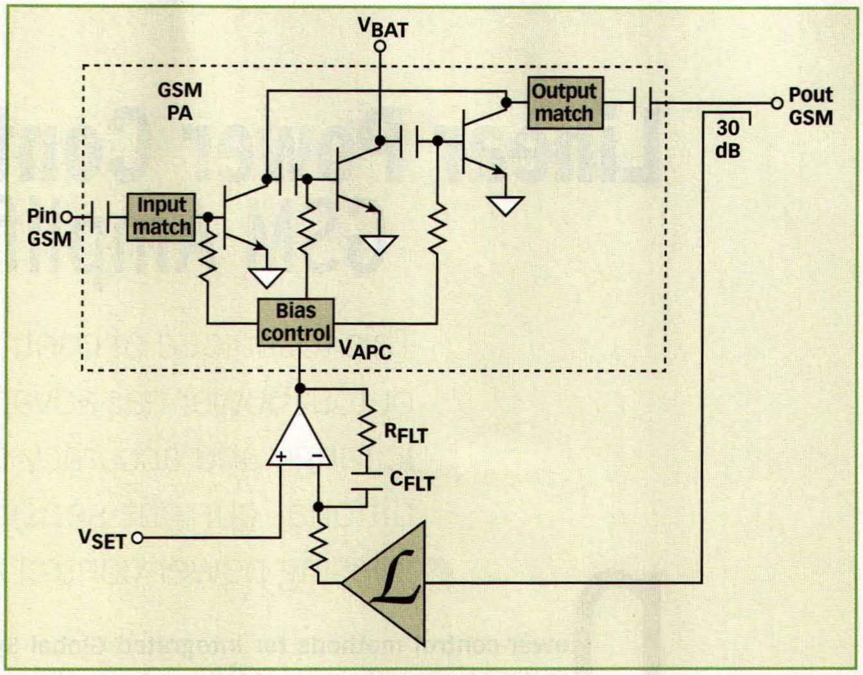
Figure 2 shows a simplified block diagram of a more accurate way to control power by directly detecting the RF power from the amplifier. The module comprises a PA, a silicon power controller, and a number of passive components. The PA output power is controlled by adjusting the bias on the bases of the power transistors. The output power is *regulated* by a classic automatic-gain-control (AGC) loop. This measures the actual output power of the PA by coupling off a small proportion of the output power using a directional coupler. The sensed power level is applied to a logarithmic amplifier (logamp). The logamp measures the power and compares it to a set point, V_{SET}. If there is a difference between the measured power and the corresponding V_{SET}, an error amplifier adjusts the voltage to the bias controller, V_{APC}.

Neither the current-sensing method nor the voltage-sensing technique have any feedback from the output of the PA. Thus, power control is nonlinear in both cases (see Eqs. 1 and 2). The output-power control function in both methods has a nonconstant slope and smaller dynamic range, making ramping to low power levels difficult.

SEE EQ. 1 IN BOX BELOW

SEE EQ. 2 IN BOX BELOW

Figure 3 shows that the output power for the RF power-detection method is linear-in-dB over all GSM power levels. This relationship is stable over temperature, and within each frequency band. The part-to-part transfer functions of the DAC that drives the controller, and the logarithmic detector both vary, however, so it is necessary to calibrate the circuit to obtain precise output power. The straightforward linear-in-dB relationship between the output power and V_{SET}, allows for a single two-point calibration in each frequency band. The procedure simply involves applying a V_{SET} that results in an output-power level close to full specified power (e.g., +33 dBm for GSM). Once achieved, the digital-to-analog converter (DAC) code is noted for that power level, which is denoted P_{HIGH}. Then, a V_{SET} is applied that results in an output power close to the minimum output-power level for that standard (e.g., +5 dBm for GSM). Similarly, the DAC code is noted for this power level, which is denoted P_{LOW}. With these four data points, the power output versus V_{SET} can be calculated. This translates into a simple two-point calibration and straight-line approximation.



2. In the RF power-detection method of PA output-power control, the output power versus control voltage (V_{SET}) transfer function is linear-in-dB over a 40-dB dynamic range.

SEE EQ. 3a IN BOX BELOW

SEE EQ. 3b IN BOX BELOW

Once the slope and the intercept are known, the required code for any trans-

$$P_{dBm} = M\log(V_{SET} - V_{LOOP\ Threshold}) + P_{OFF} \qquad (1)$$

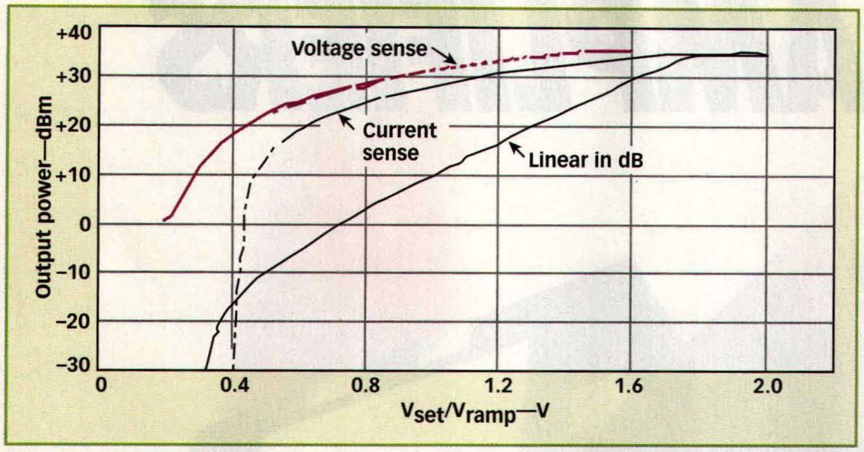
$$P_{dBm} = 10\log\left[\frac{(2V_{RAMP} - V_{SAT})^2}{8R_L \times 10^{-3}}\right] \qquad (2)$$

$$SLOPE\ (dB\ /\ CODE) = \frac{P_{HIGH} - P_{LOW}}{CODE_{HIGH} - CODE_{LOW}} \qquad (3a)$$

$$INTERCEPT\ (CODE) = P_{HIGH} - (SLOPE \times CODE_{HIGH}) \qquad (3b)$$

$$CODE = \frac{(P_{OUT} - INTERCEPT)}{SLOPE} \qquad (4)$$

$$10\log(1-\Gamma_L^2) - 10\log\frac{1+\Gamma_L}{1-\Gamma_L} = 20\log\frac{1}{1+\Gamma_L} \qquad (7)$$



3. Linear-in-dB power control allows for easy two-point calibration, whereas other control methods require more ramping profiles at lower power levels.

mit power level can be calculated using the formula:

SEE EQ. 4 ON P. 52

The RF power-detection method suffers only ±1 dB error for an output-power range spanning +5 to +34.5 dBm, while the current-sensing and voltage-sensing methods exhibit higher errors for narrower power levels.

The RF power-detection approach uses an internal 30-dB coupler. Because of this low coupling factor, the insertion loss of this coupler is extremely low (approximately 0.05 dB), and has a minimal impact on PA efficiency. This impact can be described by a loss factor of $10^{-0.05/10}$. The PAE of the amplifier module is then the PAE of the amplifier integrated circuit (IC) multiplied by this loss factor. It should be noted that all PAE specifications for the RF power-detection approach include the effect of directional coupler insertion loss.

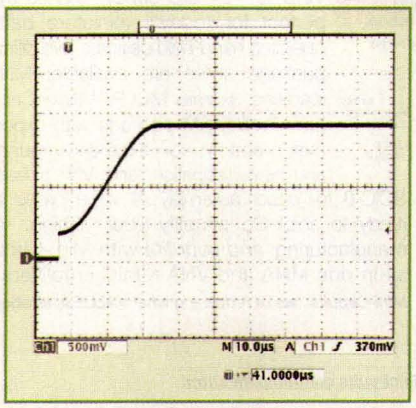
The FET used in the voltage-sensing approach has a voltage drop of about 180 mV at full power. This will also reduce the efficiency of PA chip inside the module. This loss in efficiency is approximately:

$$Loss\,factor = \frac{(V_{BAT} - 0.18)}{V_{BAT}} \quad (5)$$

This loss factor is similar to the RF power-detection approach at nominal supply voltages. However, it is worse at low supply voltages. Amplifier module PAE specifications for the voltage-sensing approach also include the PAE loss due to the FET.

The log detector controller has a control function that is linear when scaled in dB/V. To achieve the desired raised-cosine RF power profile from the PA, the ramping signal from the *ramp* DAC should also follow a raised-cosine form.

During initialization and completion of the transmit sequence, the PA bias voltage should be held at its minimum level by keeping the external control voltage at some level below 150 mV (this is generally achieved by setting the ramp DAC code to 0). The PA has a clamping mechanism designed to keep the PA off, with high isolation, when the V_{SET} voltage is below 150 mV.



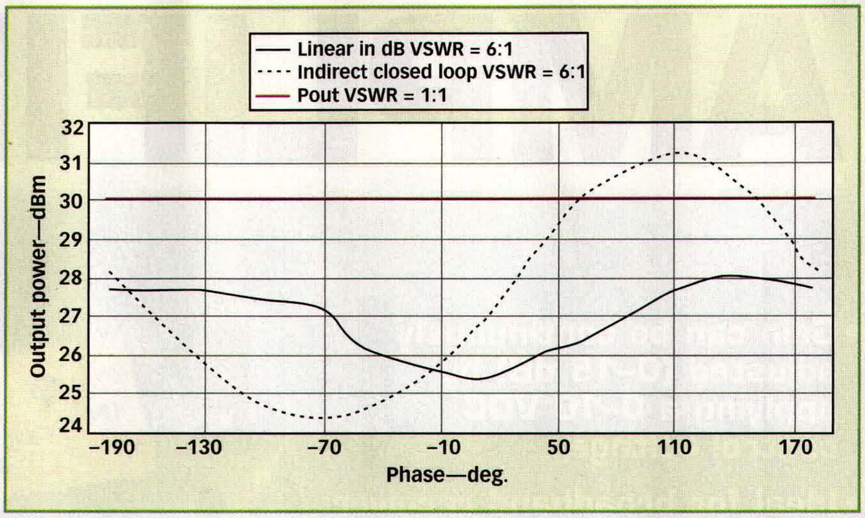
4. The filtered rising edge of ramp DAC output signals (V_{SET} drive signals) used for high-power ramping curves are based on 4× interpolation).

To optimize switching transients a step is applied to the ramp **(Fig. 4)**. The step is used because there is no point in ramping from 0 to 200 mV because the PA is designed to stay off for this voltage range.

When ramping to lower power levels, the same initial offset voltage should be applied before ramping begins. The raised-cosine portion of the ramp should be scaled to set the desired power level. The ramp-down profile can be a simple mirror image of the ramp-up signal (i.e., the same codes can be used). Alternatively, the ramp DAC signal can be a simple raised-cosine signal that falls all the way to 0 V. This is not true for the voltage-sensing and current-sensing control methods. These methods require more than one ramp profile, especially at low power levels, in order to achieve good ramping and switching transients.

A filter (C_{FLT} and R_{FLT}) must be used to stabilize the loop and ensure optimum conformance to the time mask and switching transient specifications (as shown in Fig. 2). The choice of C_{FLT} and R_{FLT} will depend to a large degree on the gain-control dynamics of the PA. The optimum values for the control loop have been determined to be 220 pF for the capacitor and 3 kΩ for the series resistor for GSM and 4.3 kΩ and 150 pF for the resistor and capacitor, respectively, in DCS/PCS systems. This gives the loop sufficient speed to follow the required ramping profiles, while still meeting the switching transient requirements at all power levels. Depending on the board layout and choice of transmit components, these values may have to be adjusted slightly. Generally, meeting these requirements is most difficult at full power.

The specific-absorption rate (SAR) is an indication of the amount of radiation that is absorbed into the body (usually the head) when using a cellular telephone. Due to strict SAR regulations, it is important to accurately control the output power of the PA. A large-impedance mismatch, e.g. 10:1, can occur at the antenna. However, due to losses in the switchplexer placed



5. For a VSWR of 6:1, the output power of the indirect closed-loop approach varies by more than ±3 dB with phase. The high-directivity directional coupler used in the RF power-detection method ensures a worst-case variation of ±1.3 dB.

between the antenna and the PA, the VSWR at the PA will be reduced, but still can be as high as 6:1. **Figure 5** shows the variation in output power due to a VSWR of 6:1 for all phase angles. The baseline output power level (i.e., a VSWR of 1:1) is +30 dBm. As expected, the baseline output power level drops due to the increased VSWR. As the phase changes, the output power of the indirect closed-loop approach varies by well over ±3 dB. In contrast, the 14-dB coupler directivity of the RF power-detection approach reduces this variation to ±1.3 dB. This translates to a 14-dB reduction in the reflected power presented to the PA.

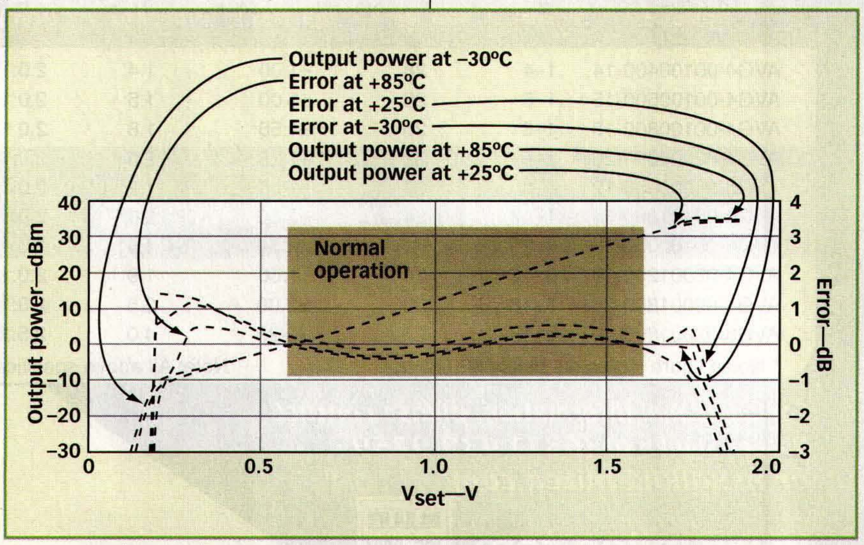
The indirect closed-loop approach operates open loop, and the output power will vary directly with the VSWR, yielding an error of:

$$Error = 10\log\frac{1+\Gamma_L}{1-\Gamma_L} \qquad (6)$$

The indirect closed-loop approach will have greater error in its transmitted output by a factor of:

SEE EQ. 7 ON P. 52

The error created by the RF power-detection approach will always result in a lower transmitted power, and thus will



6. These curves show output power versus V_{SET} for PCS (static) at +3.5 VDC.

never exceed maximum safety limits.

The accuracy of the coupler and the detector in the RF power-detection method allows for precise power control. This error of control is within ±1 dB. The required peak power out at the antenna for GSM 900 is +33 dBm. The specification allows a ±2-dB margin. The RF power-detection approach allows cellular telephones to be operated at a lower power level of +32 dBm and still meet specification, in the process saving battery life.

The accuracy of the coupler and the detector in the RF power-detection method allows for precise power control.

When the battery voltage decreases, the PA output power generally decreases. In the RF power-detection method, however, the PA output power will not decrease until the battery voltage drops below +2.9 V. This is because the closed loop senses the decreasing output power and drives the bias circuit (V_{APC}) harder, thereby keeping the output power constant.

In the indirect closed-loop approach at high battery voltages, the output power is well regulated. However, when the battery voltage to the PA decreases, the PA has trouble delivering the requisite output power. In addition, to avoid excessive switching transients at high power levels, V_{RAMP} must be limited according to the equation:

$$V_{RAMP} \leq \frac{3}{8} \times V_{BATT} + 0.18 \qquad (8)$$

As battery voltage decreases, the output power of the indirect closed-loop approach at high power also decreases. Assuming that a V_{RAMP} of 1.6 V is required to achieve full power, this limits the minimum battery voltage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to +3.25 VDC. As the battery voltage drops below this level, V_{RAMP} must also be reduced. In the case of the RF power-detection approach, the battery voltage can drop to +3 VDC before V_{SET} must be adjusted to prevent excessive switching transients. In practice, this adjustment will not be necessary as most cellular telephones are turned off at around +3 VDC.

As temperature varies, so does PA output power. The detector in the RF power-detection method detects this power change and adjusts the biasing to the PA to correct it. This method has good performance over temperatures from –30 to +85°C. **Figure 6** shows that the error is within ±1 dB and shows good linearity over all power levels within the normal output-power operating range. The indirect closed-loop approach has higher variation at lower temperatures, and requires more than one ramp profile. This increases production test time and thus final cost.

> ***As battery voltage decreases, the output power of the indirect closed-loop approach at high power also decreases.***

The linear-in-dB method described in this article is used in the models ADL5551 and ADL5552 6 × 8-mm GSM quad-band X-PA™ PA modules from Analog Devices. The inventions used in these advanced products are protected with patents and other intellectual property rights, including United States Patents Nos. 4,990,803, 4,929,909, 4,604,532, 5,572,166, 6,144,244, 6,172,549, 6,525,601, 6,489,849, and corresponding patents in other countries. MRF

Convert Distributed MICs To MMICs

Proven passive MIC components can be redesigned as MMICs with equivalent electrical performance, although at a fraction of the size and weight of their MIC counterparts.

Monolithic microwave integrated circuits (MMICs) offer considerable size and weight advantages over their microwave-integrated-circuit (MIC) counterparts. But realizing proven passive MIC components as MMIC designs can present a challenging set of trade-offs for most high-frequency engineers. To aid in the transition, some guidelines have been assembled, along with several examples of circuits that have made the switch.

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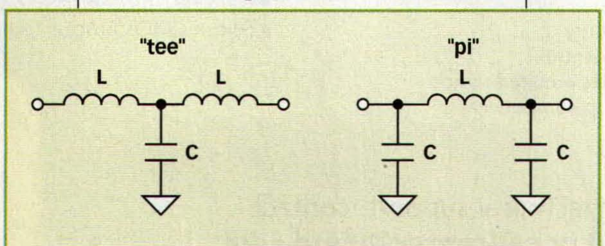
Choosing between distributed-element and lumped-element designs depends on a number of factors. Some of these include size, performance, materials, quantities, and frequency. For example, lower-frequency microwave components are often based on lumped-element designs (chip capacitors and inductors). Higher-frequency designs (2 to 30 GHz) can use lumped rather than distributed elements, although designers must be aware of the trade-offs.

At very high frequencies, even MMIC designs can employ distributed elements since quarter-wave structures become reasonably small. An example of this is a Ka-band MMIC phase shifter designed with distributed couplers, since quarter-wave elements at 32 GHz are reasonably sized for GaAs MMIC implementation.[1] Several other examples will be highlighted here, along with simulation results using linear simulation software and electromagnetic (EM) simulation software as well as measured results are shown for a 90-deg. hybrid circuit and a Wilkinson combiner using lumped elements in a GaAs MMIC.

A lossless transmission-line element can be modeled with circuit elements as a series inductor plus shunt capacitor in a pi or tee configuration **(Fig. 1)**. Given the impedance of a transmission line, the ratio of the inductance and capacitance of the lumped-element equivalent can be calculated ($Z_0 = (L/C)^{0.5}$). Once the length of the transmission line is known, it is possible to calculate fixed values for the inductor and capacitor for a given frequency. However, this transformation from lumped elements to distributed elements only works at certain fre-



1. The tee (left) and pi (right) configurations are lumped-element equivalents of a transmission line.

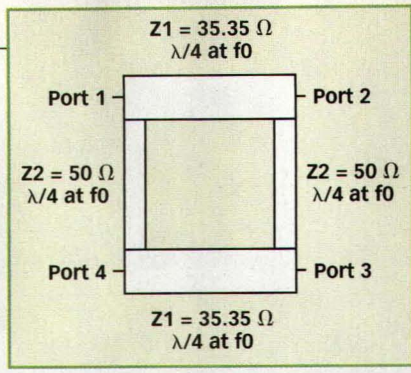
quencies. Quarter-wavelength transmission lines repeat at odd multiples of the fundamental design frequency but lumped-element equivalents do not. This can be an advantage or disadvantage depending on the design requirements. Values for the inductors and capacitors can be calculated for these quarter-wave lumped-element equivalent circuits and are found to be $L = Z_0/W_0$ and $C = 1/Z_0W_0$ where $W_0 = 2piF_0$ (where F_0 is the design frequency and Z_0 is the impedance of the transmission line). For a given impedance and frequency, there are two lumped-element circuits equivalent to the quarter-wave distributed circuits.

For a three-quarter-wavelength transmission line, inductors are substituted for capacitors and vice versa to create a highpass rather than a lowpass network. The calculated values for the L and C components are the same as the one-quarter-wave transmission-line lumped-element equivalent.

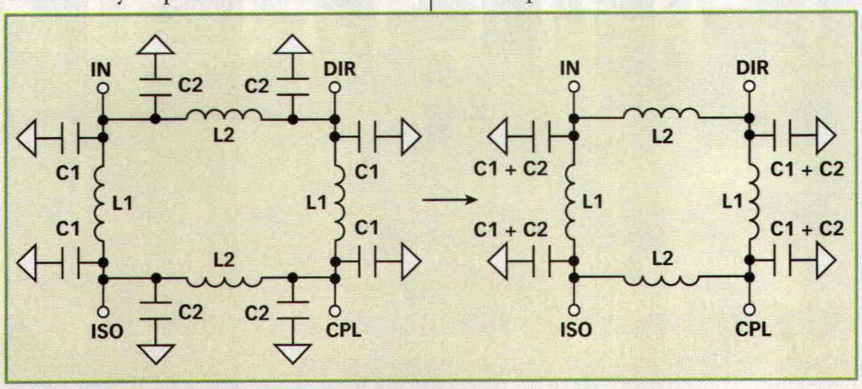
For the distributed 90-deg. hybrid, there are basically four quarter-wavelength distributed transmission lines connected in a "square" arrangement **(Fig. 2).** Two opposite transmission lines have an impedance of 50 Ω(assuming a characteristic impedance of 50 Ω) and the other two lines have an impedance of 35.35 $\Omega[(50\ \Omega)^{0.5}]$. It is very important to get the orientation of the coupler input and isolated port correct (see ref. 2).

As noted previously, there are two simple lumped-element equivalent circuits in a pi or tee arrangement. Either arrangement will work, although the choice may depend on other factors: for example, MMIC inductors tend to have more loss than MMIC capacitors. By choosing the pi arrangement to reduce the number of inductors, the lumped-element circuit of **Fig. 3** results. Note the combining of capacitors at the "corners" of the 35- and 50-Ω branches.

The branchline or 90-deg. hybrid can be used for many functions. Some of these include image-reject mixers, attenuators, phase shifters, modulators, and power combiners/dividers. This is true of both the lumped element and distributed implementations of the branchline hybrid. However, the distributed equivalent will repeat at three times the fundamental frequency. Also, the bandwidths of the two implementations are different near the fundamental frequency, F_0. The input match of the hybrid is good provided the terminations at the direct and coupled ports are nearly identical. Mismatches at the direct and coupled ports reflect to the isolated port. By adding a switch or variable resistor to the direct and coupled ports of the branchline hybrid, one can create a switched or variable attenuator using the input and isolated ports. Likewise, a switch or variable capacitor can be used to build an



2. This is a distributed representation of a 90-deg. hybrid coupler.

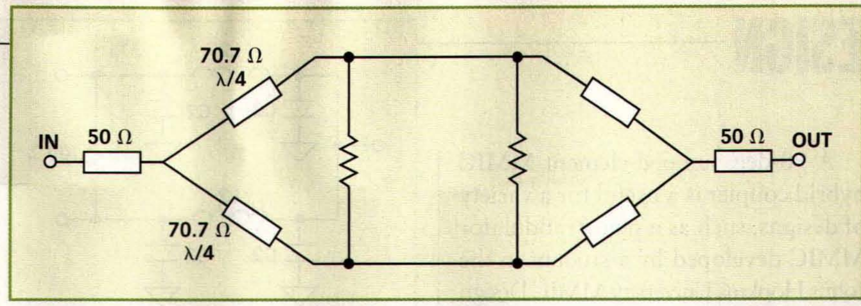


3. This is a lumped-element representation of a 90-deg. hybrid coupler.

analog or digital phase shifter or phase modulator. In an image-reject mixer, one branchline hybrid at RF helps distinguish between the upper sideband and the lower sideband of the signal. An additional 90-deg. hybrid at the intermediate frequency (IF) combines or cancels the two mixed signals to select just the upper or lower sideband.

The hybrid can also be used as a combiner or power splitter with the properties that the input match is good provided that the loads at the coupled and direct ports are matched. As a combiner, reflections from the coupled and direct port are absorbed by a resistor at the isolated port. The difficulty with the hybrid as a combiner/divider is controlling the impedances and lengths of the 35- and 50-Ω transmission lines to obtain an equal 3-dB split at the two ports.

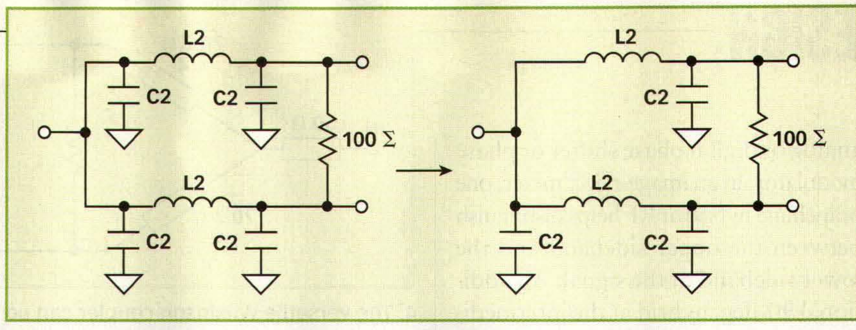
The Wilkinson coupler is often used as a power combiner or splitter. It divides an input signal equally between two outputs, or can be used to create unequal split or an n-port divider. In a Wilkinson, two quarter-wavelength 70.7-Ω lines—assuming a 50-Ω characteristic impedance—split the input to two output ports **(Fig. 4)**. A 100-Ω resistor is tied between the two output ports to provide isolation in the odd-mode case. Placing this resistor can be much easier in a MMIC lumped-element layout than in a distributed layout **(Fig. 5)**. For this example, a pi arrangement was chosen to reduce the number of lossy inductors. The input shunt capacitors combine into a single capacitor yielding two inductors, one shunt capacitor at each port, and the 100-Ω isolation resistor plus interconnect for the MMIC Wilkinson.



4. The versatile Wilkinson coupler can be used as a power divider/combiner.

As a splitter, the input is divided into two equal in-phase outputs, ideally at –3-dB levels from the input signal level. When fed at the outputs by two signals in phase and of comparable signal level, the Wilkinson acts as a power combiner. The major differences between using a Wilkinson as a divider/combiner versus the branchline hybrid is that the input match now depends on the match at the other two ports. However, it is much easier to get an equal-phase, equal-power split, as well as wider bandwidth, with the Wilkinson than with a hybrid combiner.

A 90-deg. lumped-element MMIC hybrid coupler is a useful for a variety of designs, such as a phase modulator MMIC developed by a student in the Johns Hopkins University MMIC Design Course.[3] Students in that course learn to develop practical MMIC layouts that are then fabricated at the TriQuint Semiconductor foundry. Those students developed several lumped-element hybrid layouts, planned around a central substrate via shared by four capacitors and four spiral inductors to make up the four transmission lines of the lumped element equivalent hybrid **(Fig. 6)**. Using the pi arrangement for the lumped-element branches and combining the capacitors at the ends, the layout has a single capacitance value and two inductance values that can be tuned for performance. Arranging the layout allows performance trade-offs by tuning the single capacitance and the size of the two inductors. Careful use of symmetry makes it easier to tune the circuit without "breaking" the layout. A 2.1-GHz hybrid coupler fabricated on a 34 × 54 mil die is an example of the several hybrid couplers fabricated with the TriQuint process (Fig. 6). Hybrid couplers for other frequency ranges can use the same topology by changing the capacitor and two inductor values (plus interconnect).



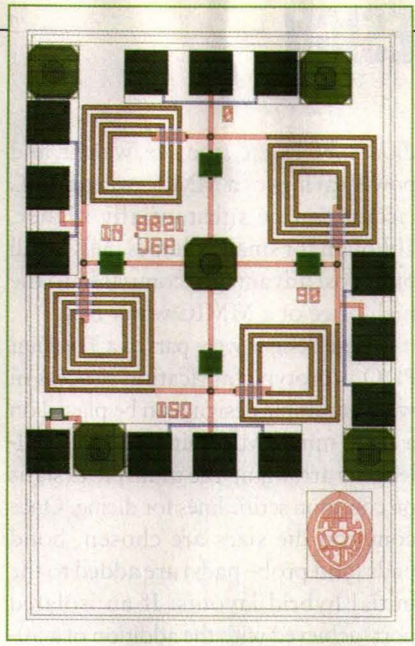
5. This is a lumped-element representation of a Wilkinson coupler.

The performance of the hybrid coupler was simulated **(Fig. 7)** with the Advanced Design System (ADS) software from Agilent Technologies and the TriQuint TQTRX device library, as well as with EM simulation software from Sonnet Software (Liverpool, NY). Only the "core" of the hybrids were simulated and assumptions were made that the effects of the ground-signal-ground probe pads and off-chip wire bonds were minimal at these frequencies. Given additional time, the matches can be tuned to offset the off-chip wire bond inductance and provide a better 50-Ω termination.

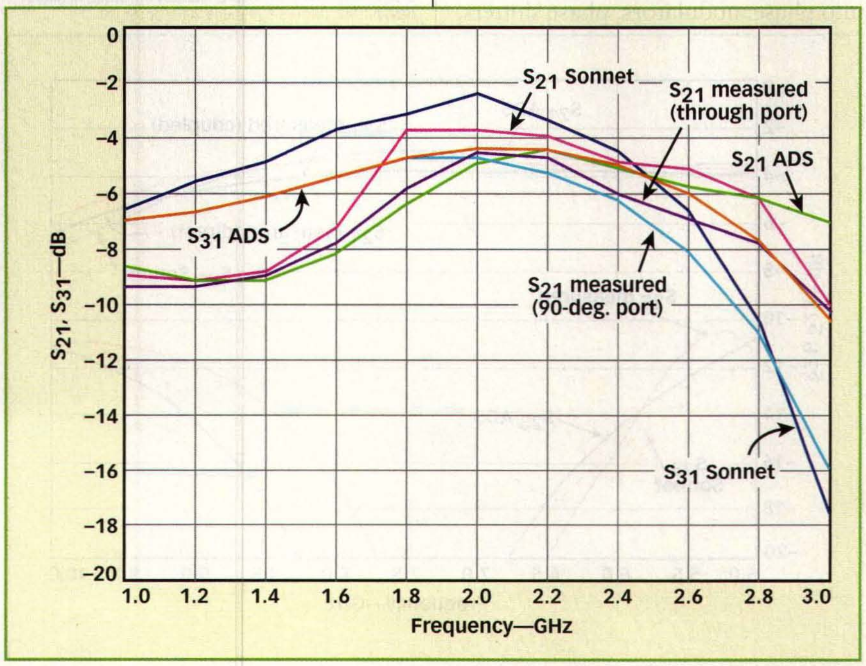
A 7.5-GHz Wilkinson divider/combiner was also fabricated with the MMIC process. It consists of two 71-Ω transmission lines and a 100-Ω resis-

tor to provide isolation for the coupled ports. Symmetry was used to ensure proper equal phase and equal amplitude split. The hybrid pi lumped-element equivalent was chosen for the MMIC implementation since it has the least number of lossy inductors. Capacitors on the input side can be combined resulting in one value for the two inductors and two values for the three capacitors—the first capacitor is twice the value of the other two. Optimizing the simulation is done by tuning the one inductor value and "one" or "two" capacitor values. A single shared substrate via was used for the shunt capacitor to ground connections. The Wilkinson was also computer simulated, although the ADS simulations did not include the isolation resistor in the layout because its effect was considered to be minimal. The layout for the 7.5-GHz X-band Wilkinson looks similar to half of the hybrid coupler layout **(Fig. 8)**. The 100-Ω isolation resistor was added to the layout along with the ground-signal-ground probe pads in the final layout using the ICED layout software.

The 7.5-GHz Wilkinson measures 34 × 29 mils, and measured performance compared closely with ADS and EM simulations **(Fig. 9)**. Various branchline hybrids from 2.1 to 8.4 GHz were all fabricated on a 34 × 54 mil MMIC tile with room to spare. The higher-frequency hybrids had some additional room for test circuits. Of course, the great advantage of MMICs over MICs is size, and a quarter wavelength on an alumina substrate (dielectric constant of 9.8), for example, is almost 600 mils. If one needs to incorporate additional circuits such as switches, varactors,



6. A 2.1-GHz MMIC hybrid coupler was fabricated on a die measuring 34 × 54 mil.

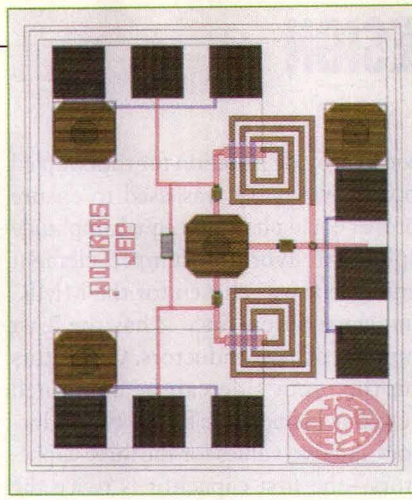


7. Measured results for the 2.1-GHz hybrid coupler compare closely with simulations using the ADS and EM modeling tools.

diodes, FETs, etc., the size, weight, and power savings of a MMIC over an MIC circuit can be substantially higher, although for small volumes, MICs still offer cost advantages compared to the high price of a MMIC wafer run.

These designs were part of a TriQuint PDQ prototype fabrication process in which multiple designs can be placed on a 7 × 7 mm MMIC mini tile. One challenge is arranging the multiple designs on common scribe lines for dicing. Once common die sizes are chosen, bond pads (and probe pads) are added to the initial hybrid layouts. If an isolated port (achieved with the addition of a 50-Ω terminating resistor) is not needed, it can be wire-bonded to a terminating resistor on the MMIC making the circuit a compact three-port coupler or as the standard four-port coupler. Text is added to identify the direct, coupled, input, and isolated ports as well as the operating frequency of the hybrid.

For those interested in fabricating only passive devices monolithically, the TQTRL process from TriQuint Semiconductor is less expensive than the company's standard process that includes active devices. Active elements, such as varactor diodes or switching elements, can turn those hybrid couplers into phase modulators, phase shifters, and attenuators. When active circuit elements are needed, however, the designer should use a full-featured process such as TriQuint's TQTRp or TQTRX process. MRF



8. A 7.5-GHz Wilkinson MMIC divider was fabricated on a die measuring 29 × 34 mil.

ACKNOWLEDGMENTS

The author would like to acknowledge his co-workers in the RF & Microwave Group of the Johns Hopkins University Applied Physics Laboratory (JHU/APL) Space Department (Laurel, MD) who supported and helped enable the MMIC designs presented here. Also, the author would like to acknowledge his co-teacher in the JHU/APL MMIC Design Course, Craig Moore, who has been a wealth of information and support for many years.

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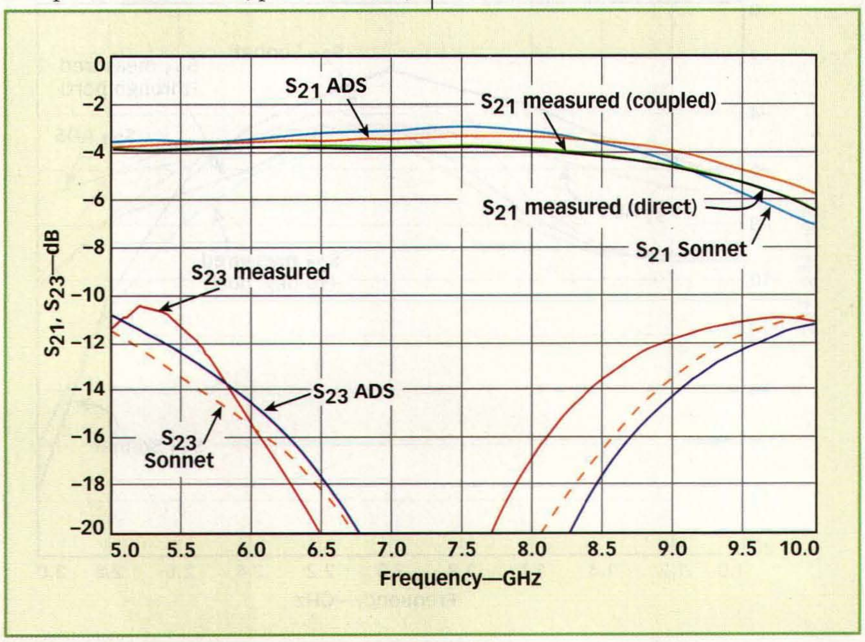

9. Measured results for the 7.5-GHz Wilkinson divider compare closely with simulations using the ADS and EM modeling tools.

Test Spectrum Analyzer ACP Dynamic Range

Published specifications for adjacent-channel power (ACP) are just one indication of a spectrum analyzer's capabilities when making actual measurements.

Spectrum analyzers must deliver wide dynamic range to keep pace with increasingly demanding requirements for evaluating third-generation (3G) wireless systems and their multicarrier power amplifiers (PAs). An analyzer's published adjacent-channel-power-ratio (ACPR) performance, however, can be misleading when the effects of measurement uncertainty are considered. By evaluating the measure-ment process and the influence of coherent and incoherent distortion, it may be possible to clarify the interpretation of spectrum analyzer ACPR dynamic range.

The wideband-code-division-multiple-access (WCDMA) ACPR[1] dynamic-range specification created by the Third Generation Partnership Project (3GPP) is of particularly interest for many engineers. The ACPR dynamic range is often used as a figure of merit for spectrum analyzers, even though instrument uncertainty can make comparisons of different instruments difficult. Many factors contribute to an instrument's overall ACPR measurement uncertainty, including dis-

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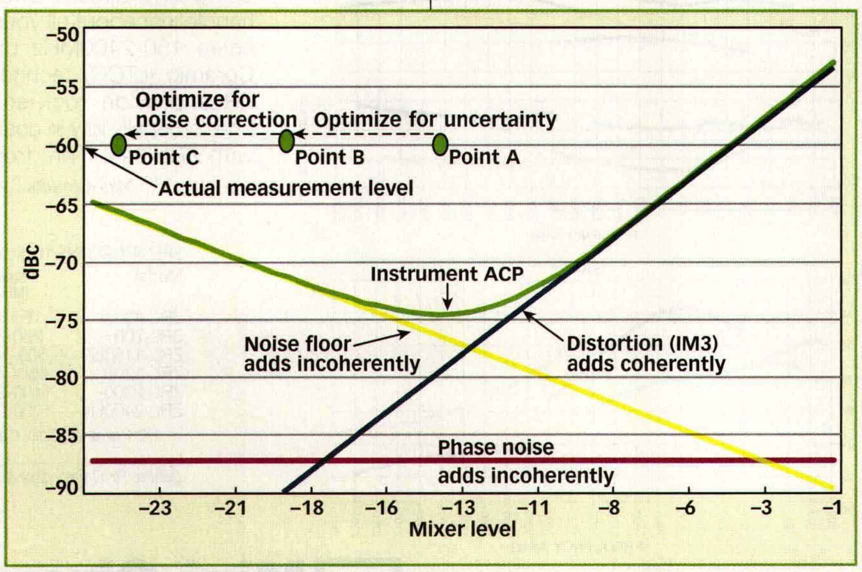
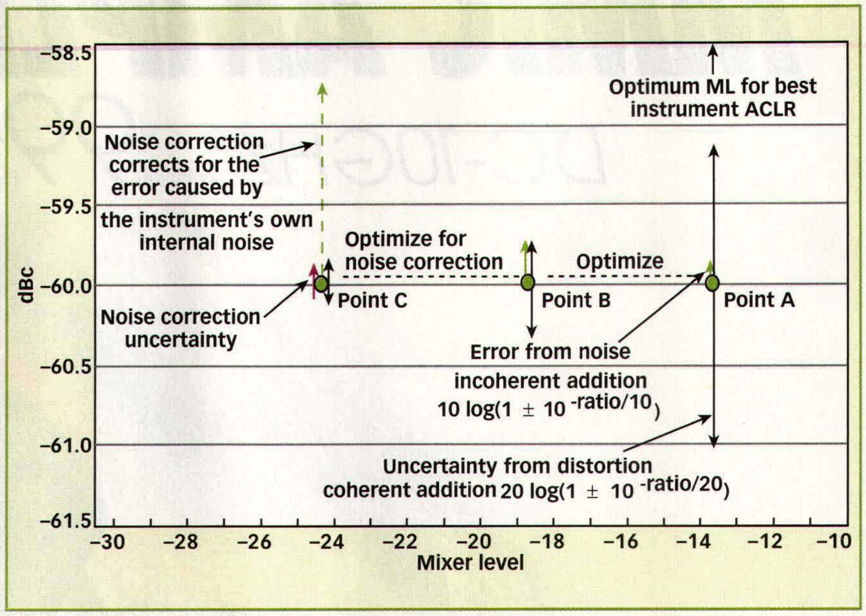


1. A spectrum analyzer's dynamic range is determined by a number of different components.



2. Instrument noise and third-order intermodulation distortion also influence a spectrum analyzer's dynamic range.

play fidelity, frequency response, and the effects of its internally generated noise and distortion. For measurements requiring high dynamic range, the most substantial source of error is typically a combination of the instrument's internally-generated noise and distortion and the noise and distortion present in the measured signal.

The dynamic range chart of **Fig. 1** shows the noise, phase noise, and third-order intermodulation distortion (IMD) of the instrument as a function of its mixer level.[2] The curve labeled "Instrument ACP" is a summation of the other curves, and yields the spectrum analyzer's internal ACP. The optimum (lowest) ACP of –74.5 dB occurs at a mixer level of –13.5 dBm.

In practice, a level of –74.5 dB would never be measured because the ACP of the DUT will add with the ACP of the instrument to produce another value.[3] In this case, the DUT ACP performance of –74.5 dB will add with the analyzer's ACP power and, in the best case (when the signals are completely incoherent), the displayed result will be –71.5 dB.

To avoid errors caused by reduced signal-to-noise and signal-to-distortion ratios, the common rule is that the analyzer should have 10 to 15 dB greater dynamic range than the DUT to be measured. However, as this example shows, this may not be an adequate way to ensure an acceptable amount of measurement uncertainty.

Third-Order IMD

The noise-like nature of digital signals makes it seem reasonable that the third-order IMD generated by the instrument will be incoherent with the third-order IMD generated by the DUT. However, this is generally not the case. The distortion is in fact coherent and will add as voltage rather than power, resulting in higher-than-expected measurement uncertainty.

One way to understand distortion coherence is to visualize the envelope of a test signal. Nonlinearities in the DUT and in the front end of a spectrum analyzer will usually compress the peak envelope excursions. If both the DUT and the spectrum analyzer compress the peaks at the same instant, the effects will add coherently as voltage errors and the distortion products will add (or subtract depending on the phase of the signals).[1]

How does this affect the measurement? If incoherence is assumed, then the most logical way to make the measurement

is to set the input attenuator to achieve a mixer level at the minimum point on the ACP curve. The error caused by incoherent addition will always be positive, so it is reasonable to obtain the optimum measurement setting by simply adjusting the attenuator until the best (minimum) reading is observed. Unfortunately, the characteristics of coherence complicate the matter. This is because coherent addition can be positive or negative (depending on the unknown phase relationship), so adjusting the mixer level to achieve the best reading can result in an optimistic but erroneous result.

Consider the ACPR measurement of –60 dB in **Fig. 2** that was achieved at a mixer level of –13.5 dBm. For the incoherent case, this would be the optimum mixer level setting, and the resulting error caused by the internal ACP of the analyzer would be +0.15 dB, resulting in a reading of –59.85 dB. However, if coherent distortion is present, as it is likely to be, the total error could be +1.00 dB to –1.05 dB, producing a measurement range of –59.0 to –61.05 dB.

Larger Errors

Larger errors will result from measurements made close to the coherent distortion curve than from measuring close to the incoherent noise curve (see Figs. 1 and 2). The optimum measurement setting is determined by increasing the attenuation, which lowers the spectrum analyzer's mixer level, as illustrated in Figure 2. Assuming the distortion and noise curves follow a straight line on the dynamic range chart as theoretically predicted, the optimum amount that the mixer level should be shifted depends on the level of DUT ACPR, and can be estimated using the equation:

$$ML_{shift} \approx \left(\frac{1}{3}\right)\left(ACPR_{analyzer}\right) - ACPR_{DUT}$$

While the distortion curve of all spectrum analyzers varies somewhat from an ideal value, it varies significantly in some instrument models. It is the basic reason why an instrument

with high specified dynamic range does not always produce better measurement results than a unit with lower specified performance. This does not mean that more dynamic range is not always desirable for making better measurements, but that the instrument's optimum settings for a specific measurement are the ones of significance, rather than the dynamic range it achieved with the optimum settings specified in data sheets and other literature.

To illustrate this point, consider the measured third-order-intercept (TOI) surface plots of **Figs. 3a and 3b** comparing two spectrum analyzers. By definition, TOI is the theoretical point where the third-order IMD curve resulting from two tones will intercept the axis (0 dBc). The graphs show TOI as a function of mixer level and tone separation.

> ***One way to understand distortion coherence is to visualize the envelope of a test signal.***

Theoretically, the surface plots should be flat. In reality, they vary depending on the mixer level and tone separation. While analyzer A has the best maximum TOI, it does not have the best TOI for all mixer levels and tone spacing. A single TOI specification may not tell the full story of the instrument's distortion performance. In addition, instrument makers may choose different settings to qualify their specification, taking either aggressive or conservative approaches. Consequently, comparing instruments specification for specification can be an unreliable way to evaluate them.

Third-order spectral regrowth generated by a digitally-modulated signal can be loosely correlated to two-tone, third-order IMD. The spectrum analyzer's distortion curves for an ACP measurement of a digitally modulated signal will therefore exhibit similar behavior with the performance varying depending on the measurement bandwidth, which is directly related to the noise level and optimum mixer level, and adjacent-channel spacing.

Assuming that the spectrum analyzers in Figs. 3a and 3b have similar internal noise levels, analyzer A will have better minimum ACPR for measurements with the wider measurement bandwidths and channel spacing typically used for WCDMA because of its higher noise floor and therefore higher optimum mixer levels. Analyzer B would perform better measuring the narrower bandwidths and close channel spacing typically used for cmda2000, multicarrier GSM, and multi-tone signals, because of its lower noise floor and therefore lower optimum mixer levels. However, even for tests with wide measurement bandwidths, the effective dynamic range of analyzer A may not be better for an actual measurement.

For a wide-bandwidth ACPR measurement, the ACP third-order spectral regrowth curve for the two spectrum analyzers might look like the example in **Fig. 4.** While the distortion of analyzer B is relatively predictable, the distortion of analyzer A degrades significantly at lower mixer levels. Although analyzer A would have better minimum ACPR performance, its effective dynamic range from an accuracy perspective is limited once the mixer level is optimized for better measurement uncertainty.

The larger-than-expected uncertainty effects caused by distortion may particularly affect the measurement if noise correction is used. Many modern spectrum analyzers have an automated noise correction function that if performed properly can dramatically reduce measurement uncertainty and extend the instrument's effective dynamic range. The noise-correction technique makes the analyzer measure its internal noise, calculates its error contribution to the measurement, and subtracts the error out of the final result.

The effectiveness of noise correction depends on how accurately and repeatably the instrument can measure its own noise relative to the ACP measurement. Although some uncertainty is introduced into the measurement

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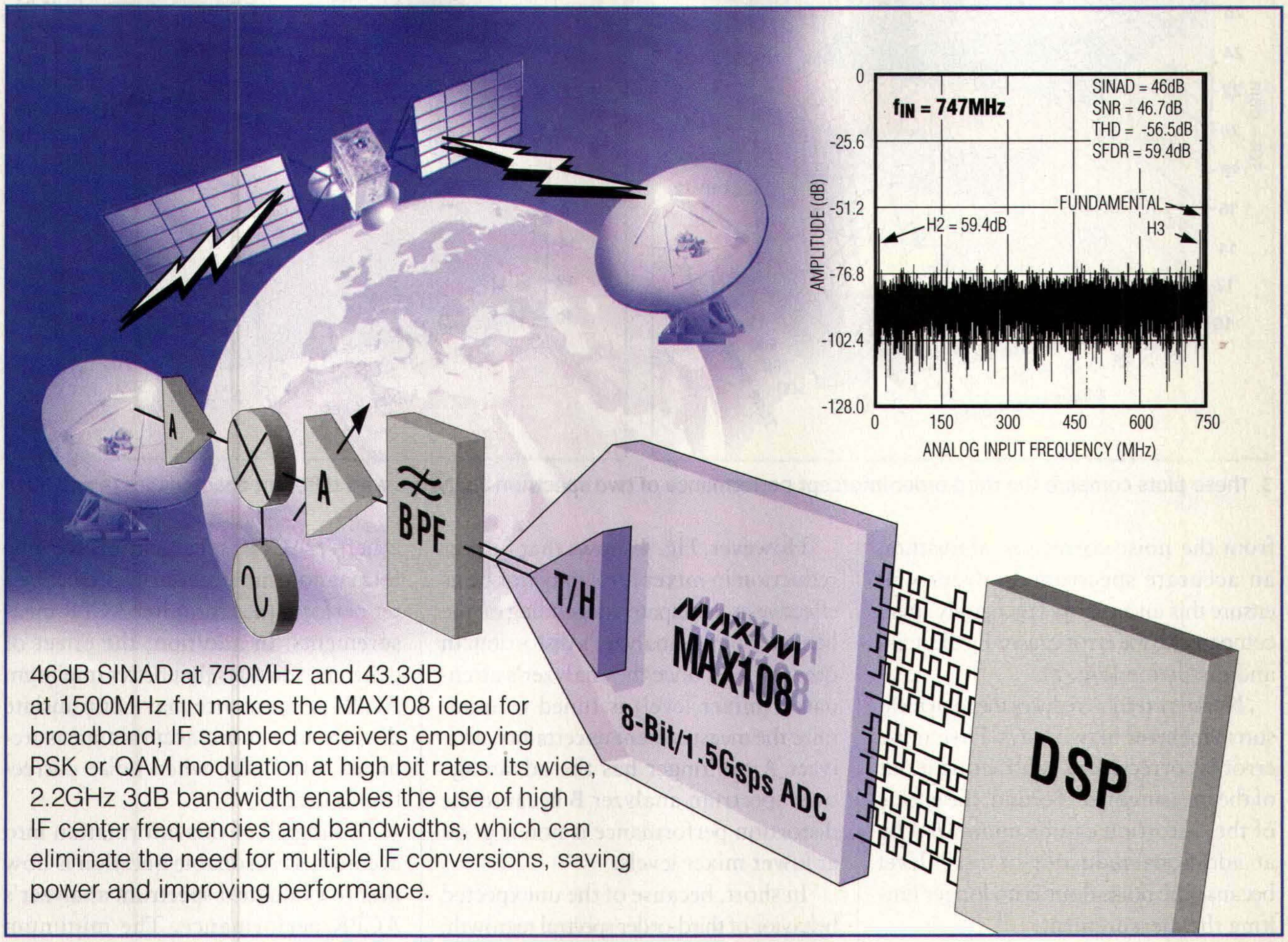

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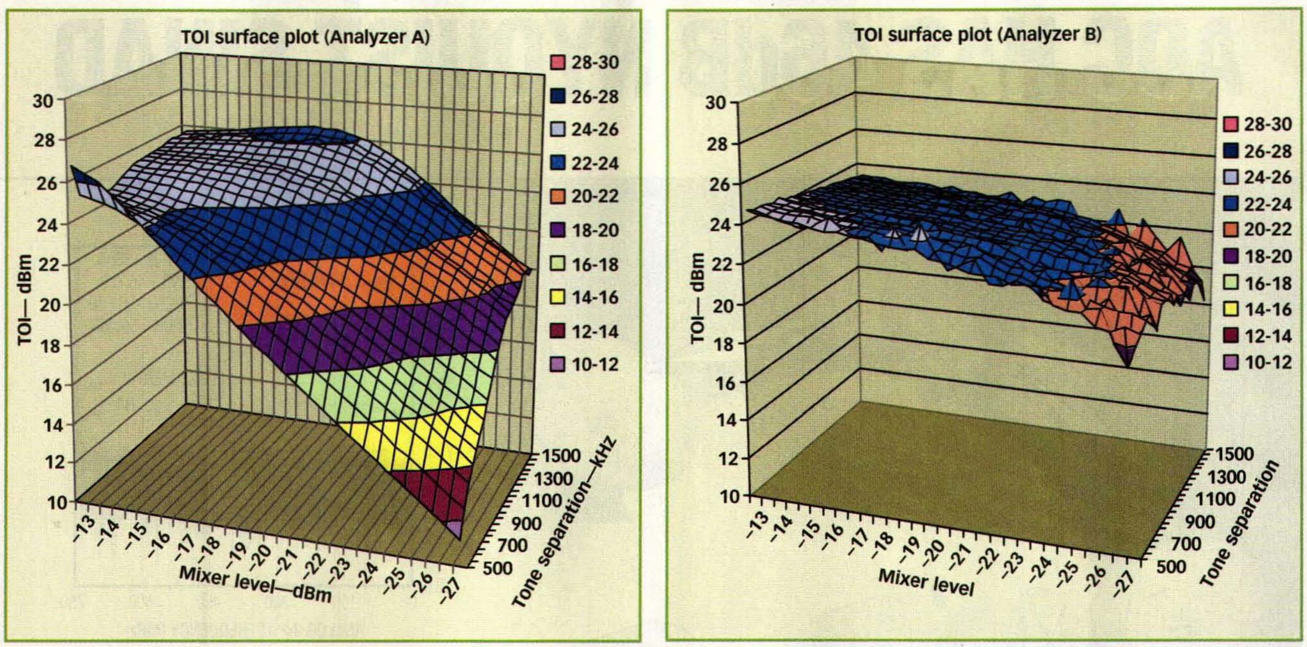


3. These plots compare the third-order-intercept performance of two spectrum analyzers with different chacteristics (a and b).

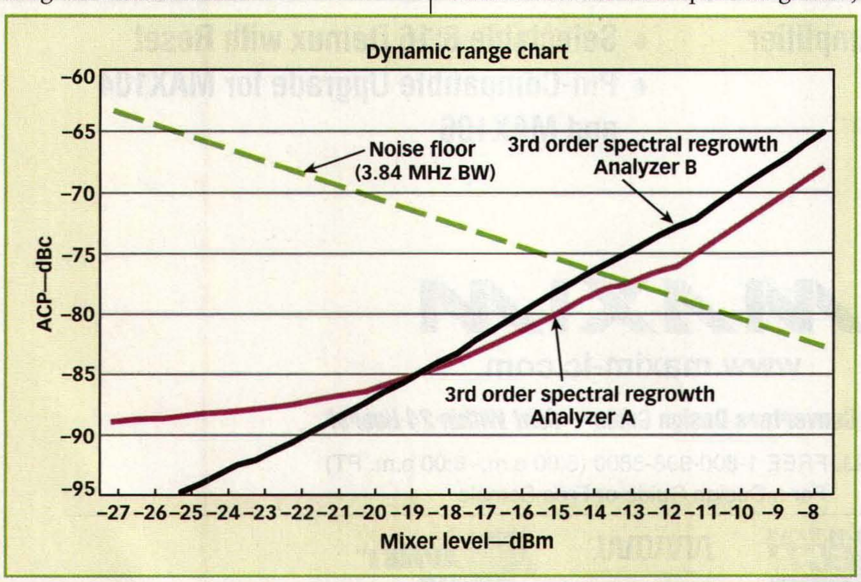
from the noise-correction algorithm, an accurate spectrum analyzer will ensure this uncertainty is generally small compared to the error caused by the noise and distortion (Fig. 2).

Noise correction reduces the total measurement error in two ways. First, noise error is corrected by subtracting it out of the measurement. Second, the effects of the distortion can be minimized by an additional reduction of mixer level because the noise floor is no longer limiting the measurement.

However, Fig. 4 shows that further reduction in mixer level may not be as effective as anticipated depending on the behavior of the analyzer's distortion. In other words, once the analyzer's attenuator (mixer level) is tuned to minimize the measurement uncertainty, analyzer A no longer has the advantage over spectrum analyzer B because the distortion performance is not as good at lower mixer levels.

In short, because of the unexpected behavior of third-order spectral regrowth, a better ACPR specification for one format does not necessarily predict better performance for other ACPR measurements. In addition, the effect of coherence dictates that better minimum ACPR performance may not translate directly into more accurate measurements, especially when noise correction is used.

Taking all of this information into account, a reasonable question is how best to evaluate a spectrum analyzer's ACPR performance. The minimum ACPR dynamic range specification should not be disregarded altogether, but a closer examination should be made to substantiate it.



4. These plots compare the third-order spectral regrowth performance of two spectrum analyzers with different chacteristics (a and b).

The First Step

The first step is to see if ACP performance is included in the specifications guide or data sheet for the instrument. ACP performance included in brochures and marketing literature is sometimes not substantiated by solid specifications. If possible, compare the ACPR accuracy specification based on a required measurement level. If the accuracy specification is not available, ask the vendor to supply it for incoherent and coherent scenarios.

It is also beneficial to compare the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dynamic-range specifications for other ACP measurements including other formats or test setups. This can indicate the consistency of the analyzer's distortion performance. Checking the instrument's TOI specification may also be a good indicator, in particular the mixer levels and tone spacing to which the TOI specification applies. Running a side-by-side comparison of two instruments making measurements using different formats, measurement bandwidths, channel spacing, and tone spacing, can be revealing as well.

Overall, it is important to remember that the requirement for more dynamic range is really a requirement for better measurement uncertainty and repeatability. It is not which analyzer has the better dynamic-range specification that counts, but which analyzer can make the required measurements more accurately. MRF

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2. Application Note 150, 1212, "Spectrum Analyzer Basics," Agilent Technologies, Santa Rosa, CA, June 1, 2000.
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Microwave Component Mechanics

HARRI ESKELINEN AND PEKKA ESKELINEN

MACHINE SHOPS do not often receive the credit due them for the fabrication of many microwave components. In fact, precision machining is a critical element in the realization of most microwave components, and is an often taken-for-granted skill in the design and manufacturing of high-frequency components. *Microwave Component Mechanics* by Harri Eskelinen and Pekka Eskelinen, one of the first texts devoted to the mechanical aspects of designing and manufacturing microwave components, finally brings credit to precision machine shops and the people who work in them.

The text is directed at both mechanical and electrical engineers desiring to benefit from increased knowledge in microwave component design and engineering. The opening chapter covers the special requirements for microwave components, and reviews Maxwell's equations, the effects of high-frequency propagation, and the influence of different materials and dimensional tolerances on microwave circuits. Chapter 2 introduces a systematic flowchart model designed to ease the transition of prototypes to production. Chapter 3 reviews the various materials available for constructing microwave components, while Chapter 4 examines the place of computer-aided-design (CAD) tools for creating microwave components. Chapter 5 covers instructions for technical documentation, while Chapter 6 studies the effects of production volumes on manufacturing costs.

Chapter 7 begins a section of the book dedicated to manufacturing technologies for passive microwave components, with a focus on welded components. Chapter 8 reviews various other metal-joining technologies, including screw and adhesive joints. Chapter 9 details machining technologies and how they can be applied to the manufacture of various components, including rotary joints and filters. Chapter 10 reviews cutting processes, while Chapter 11 highlights forming processes, including injection molding, extrusion processes, and electroforming processes. Chapter 12 covers coatings, Chapter 13 examines a measurement system, and Chapter 14 investigates the design of different antennas. The final four chapters cover test equipment and measurement systems.

Microwave Component Mechanics seamlessly details key aspects of mechanical and electrical design and manufacturing required for achieving high-performance microwave components. The book is shipped with a CD-COM containing many of the test-case prototype drawings and test results, including three-dimensional CAD drawings. (2003, 368 pp., hardcover, ISBN: 1-58053-368-X, $89.00.) **Artech House, Inc., 685 Canton St., Norwood, MA 02062; (781) 769-9750 ext. 4030, FAX: (781) 769-6334, e-mail: artech@artechhouse.com, Internet: www.artechhouse.com.**

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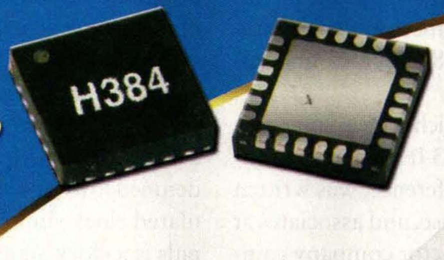

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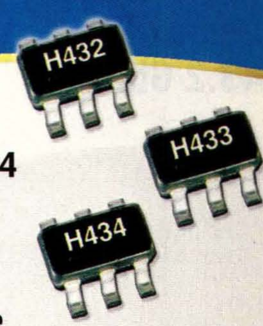

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Clock and Data-Recovery IC Includes Demux For 43.2 Gb/s

CLOCK AND DATA RECOVERY circuits must operate beyond 40 Gb/s to handle the increasing demands for high-speed data in next-generation optical communications systems. An application note from Inphi Corp. (Westlake Village, CA), "A Fully Integrated 43.2 Gb/s Clock and Data Recovery and 1:4 DEMUX IC In InP HBT Technology," describes one such integrated solution for OC-768 optical-communications architectures.

The three-page note, which is based on a presentation made at the 2003 IEEE International Solid-State Circuits Conference, was written by Jeffrey Yen, Michael Case, and associates at Inphi, a fabless semiconductor company gaining notoriety for its line of 25-GHz microwave prescalers. In the note, readers learn about the operation of this high-speed integrated circuit and how to extract optimum performance in their own circuits. Measurements made with an external chip capacitor mounted on a wafer probe card reveal root-mean-square (RMS) jitter of less than 1 ps for the recovered clock signals. Measurements were made on a die of 10.2 mm^2 area at +3.3 VDC, with little or no change in the measured values with ±5 percent supply variations. At that supply voltage, the power consumption was 3.3 W. The measured input sensitivity for bit-error rates (BERs) below 10^{-12} is 27 mV peak to peak differential. The jitter tolerance was measured in two steps because of the limited modulation bandwidth of the pattern generator clock source. For lower-frequency jitter, the pattern-generator clock source is directly phase modulated by a sinusoid signal. For higher-frequency jitter testing, a balun is used to add a slightly frequency-detuned low-amplitude sinusoid to the unmodulated clock sinusoid. The sum of the two signals is a clock signal with low jitter amplitude and jitter frequency equal to the frequency detuning of the low-amplitude source.

The IC is implemented in a production indium phosphide (InP) heterojunction-bipolar (HBT) based on 100-mm wafers and 1-μm emitters. A free copy of the note can be downloaded from the company's website.

Inphi Corp., 2393 Towngate, Suite 101, Westlake Village, CA 91361; (805) 446-5100, FAX: (805) 446-5190, Internet: www.inphi-corp.com.

The push-pull amplifier is well suited for wideband code-division-multiple-access (WCDMA) communications systems requiring high linearity and efficiency.

Push-Pull Amplifier Drives IMT-2000 Base Stations

HIGH-POWER AMPLIFIERS ARE among the most critical (and expensive) components in a wireless base station. Application note No. 004 from Fujitsu Compound Semiconductor (San Jose, CA), "150-W, 2.11-2.17 GHz Push-Pull Amplifier for IMT-2000 Base-Station Application Using the FLL1500IU-2C GaAs FET Device," provides the design and construction details needed to assemble an efficient power amplifier for IMT-2000 applications based on a commercial 150-W GaAs transistor.

The push-pull amplifier is well suited for wideband code-division-multiple-access (WCDMA) communications systems requiring high linearity and efficiency. The amplifier can operate over the full 2.11-to-2.17-GHz WCDMA band with adjacent-channel-power-ratio (ACPR) performance of typically –42 dBc at 20-W (+43-dBm) output power.

As the note details, the push-pull approach offers several advantages over a balanced amplifier configuration. For example, the push-pull amplifier provides better stability, with simpler external impedance matching and better isolation between sides of the transistor device than a balanced amplifier approach. The push-pull design also lends itself to easier-to-design quadrature couplers that can be readily integrated into the amplifier layout.

The FLL150IU-2C device is essentially two pairs of 40-W GaAs FETs mounted in the Fujitsu IU package. The package has two gates and two drain connections. Impedance matching networks are used within the package to raise the input and output impedances to a 50-Ω characteristic impedance.

The 16-page application note provides full details about the DC bias circuitry required for optimum performance, as well as tuning approaches for linearity and efficiency. Copies of the note are available for free download from the company's website.

Fujitsu Compound Semiconductor, Inc., 2355 Zanker Rd., San Jose, CA 95131; (408) 232-9500, FAX: (408) 428-9111, e-mail: sales@fcsi.fujitsu.com, Internet: www.fcsi.fujitsu.com.

cover story

Instrument Checks GPS Noise Immunity

This single-unit system can create arbitrary waveforms as wide as 40 MHz and CW signals to 2 GHz for checking the immunity of GPS receivers to noise and interference at L1, L2, and L5 frequencies.

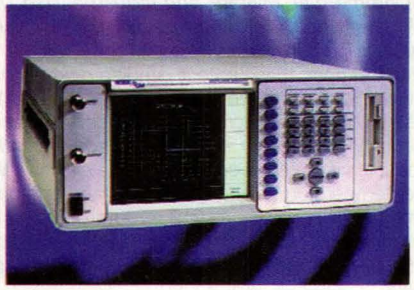
BENT HESSEN-SCHMIDT
Executive Vice-President of Marketing
Noise Com, Inc., 25 Eastmans Rd., Parsippany, NJ 07054; (201) 261-8797, FAX: (201) 261-8339, e-mail: info@noisecom.com, Internet: www.noisecom.com.

Global Positioning System (GPS) receivers (Rxs) now have widespread use in aircraft landing systems, shipborne navigation systems, and E-911 civil emergency location systems. Due to political threats and increasingly occupied bandwidth, dual-frequency GPS Rxs have been developed to overcome the effects of interference. Since such Rxs must perform accurately even under conditions of interference, Noise Com (Parsippany, NJ) has developed the GPS7500 Noise & Interference Generator, a single self-contained instrument that supports all GPS interference testing requirements, including for L1, L2, and L5 frequencies.

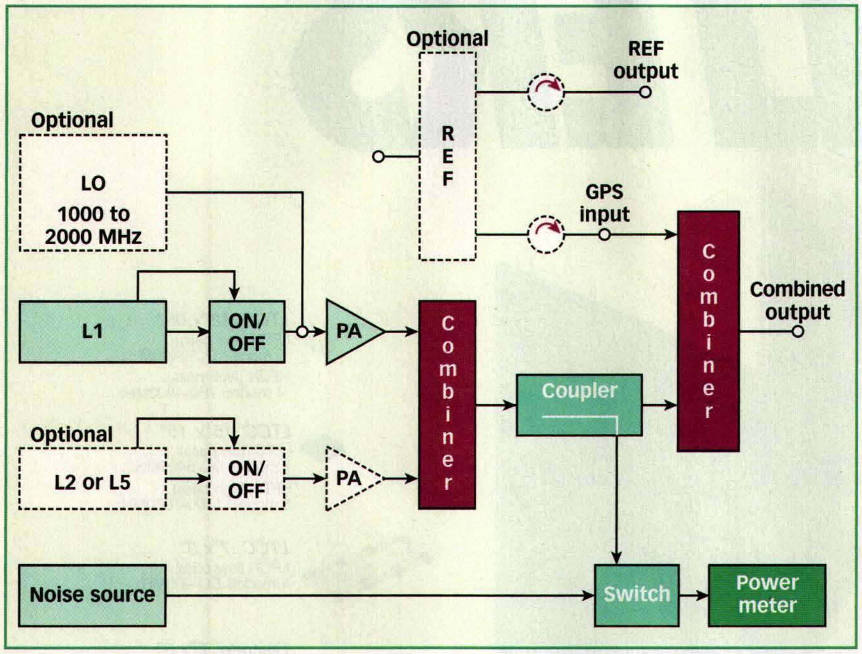
The effects of noise and interference on a GPS Rx range from decreased accuracy to loss of lock. Documents DO-229, DO-235 and DO-253 from the Radio Technical Commission for Aeronautics describe 13 test cases for GPS interference, including broadband noise interference, continuous-wave (CW) interference, and pulse interference. In addition, potential emerging interference sources, such as ultra-wideband (UWB) (pulsed) communications signals, have been studied and added to this documentation.

GPS interference testing is not trivial. Stable, low-level GPS signals must be combined with known levels of noise and interference, for example, generating pulsed interference at levels above +20 dBm with on/off ratios exceeding 164.5 dB while also preventing phase noise from skewing the test results.

The GPS7500 **(Fig. 1)** was developed as a solution for such testing.

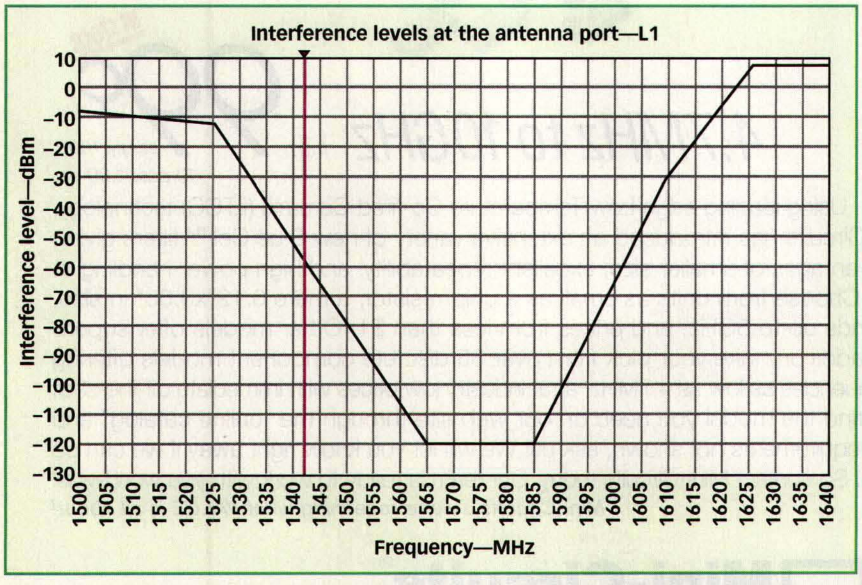


1. The GPS7500 Noise & Interference Generator can generate the arbitrary waveforms needed to emulate noise and interference for immunity testing of L1, L2, and L5 GPS receivers.



2. This block diagram shows the basic elements of the GPS7500, with one or two arbitrary waveform generators, precision noise source, and power meter.

The modular instrument can be supplied with one or two arbitrary waveform generators for simultaneous testing of L1 (1575.42 MHz) and L2 (1227.60 MHz) or L5 (1176.45 MHz) GPS signals. It also includes frequency upconverters and an elaborate signal switching and combining network. The waveform generators incorporate digital filtering and over sampling with interpolation to create nearly spurious-free intermediate-frequency (IF) signals which are then upconverted to the desired RF range. The GPS7500 also features two 1-to-2-GHz CW frequency generators for out-of-band interference signals at levels beyond +20 dBm. A built-in power meter ensures accurate calibration of signal and interference levels, while a calibrated noise source serves as a low power reference in support of a 100-dB dynamic range **(Fig. 2)**.



3. The front-panel display of the GPS7500 was used to show these GPS interference curves as specified in RCTA document DO-253A.

The interference and noise generator has three operating modes: synthesized CW modem arbitrary interference mode, and pulse mode. In the CW mode, the instrument offers an operating range of 1000 to 2000 MHz with 20-kHz frequency resolution and ±0.5 PPM frequency stability. In the CW mode, the phase noise is –122 dBc/Hz offset 100 kHz from the carrier and spurious levels are –80 dBc offset 21.5 MHz from the carrier.

In the arbitrary interference mode, the generator can create arbitrary noise and interference signals, such as amplitude modulation (AM), with 3-dB bandwidths from 0 to 40 MHz. The phase noise is –46 dBc/Hz offset 20 kHz from the carrier while spurious levels are better than –52 dBc offset 21.5 MHz from the carrier. In the pulse mode, the generator can create pulses as narrow as 6.67 ns with duty cycles from 0 to 100 percent at pulse repetition rates of 5 Hz to 75 MHz. The generator achieves a minimum pulse on/off ratio of 164.5 dB. It can control signal levels from –126.5 to +10 dBm from 1000 to 2000 MHz, and has a low-noise mode that drops the signal/noise floor to –170.5 dBm measured in a 1-Hz bandwidth.

The GPS7500 operates under the control of a Pentium processor running the Windows XP operating system. Since GPS Rxs capture and decode signals at levels close to the natural noise floor, the GPS7500 employs special calibration routines to measure and calibrate in-band interference. The instrument's internal hard drive includes time-saving preset templates, which follow the bandwidth, power, and frequency combinations for DO-253A testing **(Fig. 3)**. Additional arbitrary waveforms with as much as 42 MHz of bandwidth can be created by means of the GPS7500's embedded personal computer (PC) or imported using the Ethernet interface. **Noise Com, Inc., 25 Eastmans Rd., Parsippany, NJ 07054; (201) 261-8797, FAX: (201) 261-8339, e-mail: info@noisecom.com, Internet: www.noisecom.com.**

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Management Makeover Marked By New Packages

Technological progress continued at a leading supplier of high-speed, high-frequency packaging, buoyed by the news of a recent management buyout.

JACK BROWNE
Publisher/Editor

Innovative engineering often continues with or without the blessing of management. In the case of package supplier StratEdge (San Diego, CA), even the loss of venture capital did not deter the company's progress in hermetic high-frequency packaging, as evidenced by the introduction of a line of discrete semiconductor packages for applications from DC to 18 GHz. Ideal for two-terminal semiconductor devices, these low-cost hermetic surface-mount housings are also well suited for devices based on RF microelectromechanical systems (MEMS) technology.

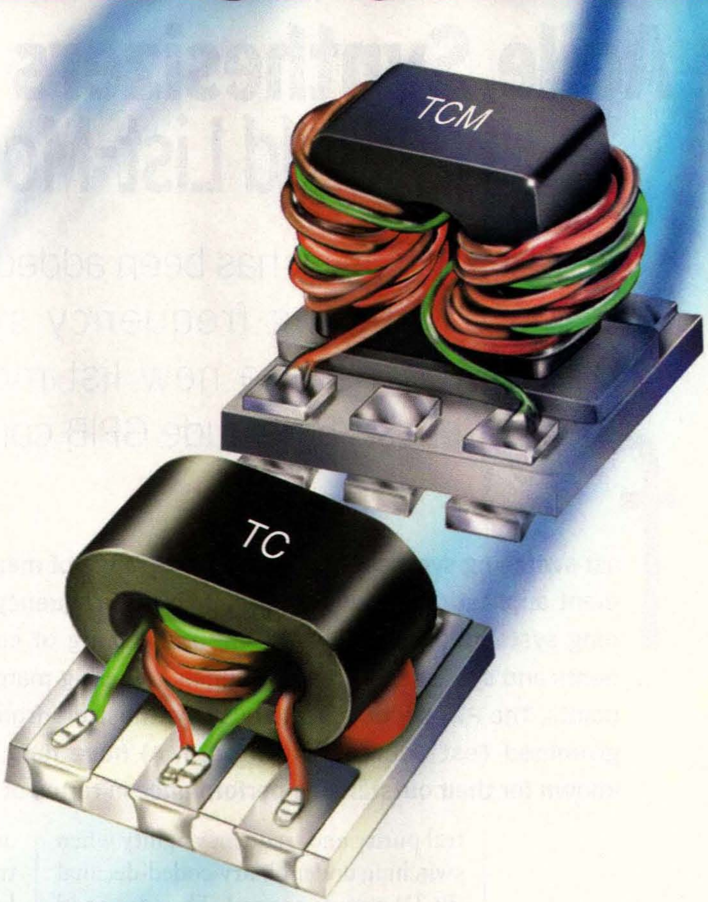
A variety of package lead configurations are available, ranging from tiny two- and three-lead packages to larger 52-lead housings suitable for logic circuits, digital-to-analog converters (DACs), and multiplexers. The smallest of the new housings compete with micro-X style housings for discrete transistors and other two-terminal devices.

The packages, which can be supplied with lead profiles meeting JEDEC standards, are capable of meeting MIL-STD-38535 requirements for demanding military and aerospace applications, although low enough in cost to meet many commercial requirements. As an example of the new line, the model G1111M-1 housing was developed for an RF MEMS single-pole, double-throw (SPDT) switch with heterojunction-bipolar-transistor (HBT) gain stage. The six-lead (three RF connections and three power-supply connections) package measures 3 × 3 mm (0.118 × 0.118 in.) with an internal cavity of 0.88 × 0.88 mm (0.035 × 0.035 in.).

Similarly, the G1010M-9 package is designed for silicon bipolar or field-effect-transistor (FET) transistors. This package measures 2.5 × 2.5 mm (0.098 × 0.098 in.) with an internal cavity of 0.76 × 0.76 mm (0.030 × 0.030 in.). Both two- and three-lead versions of the G1010M-9 are available. Additional members of the low-cost hermetic surface-mount package line include the eight lead model G1616M-1 (4.2 × 4.2 mm), the 32-lead model G2121M-7 (5.4 × 5.4 mm), and the 52-lead G4040M-5 (10 × 10 mm).

The introduction of these packages comes during a management buyout of the company. Founded in 1992 and previously funded by a venture capital firm, StratEdge is now owned by its managers. According to Tim Going, former vice-president of sales and marketing and new president of StratEdge, "The new structure will result in a more stable and customer-driven organization." P&A: $2.00 (1000 qty.)(two- or three-lead package); stock. **StratEdge, 4393 Viewridge Ave., San Diego, CA 92123; (858) 569-5000, FAX: (858) 560-6877, e-mail: sales@stratedge.com, Internet: www.stratedge.com.**

RF TRANSFORMERS



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TC1-1T	1A	0.4-500	1-100	1.19
TC1-1	1C	1.5-500	5-350	1.19
TC1-15	1C	800-1500	800-1500	1.29
TC1.5-1	1.5D	.5-2200	2-1100	1.59
TC2-1T	2A	3-300	3-300	1.29
TC3-1T	3A	5-300	5-300	1.29
TC4-1T	4A	.5-300	1.5-100	1.19
TC4-1W	4A	3-800	10-100	1.19
TC4-14	4A	200-1400	800-1100	1.29
TC8-1	8A	2-500	10-100	1.19
TC9-1	9A	2-200	5-40	1.29
TC16-1T	16A	20-300	50-150	1.59
TC4-11	50/12.5D	2-1100	5-700	1.59
TC9-1-75	75/8D	0.3-475	0.9-370	1.59

LEADS Plastic Base (actual size)

MODEL	Ω Ratio & Config.	Freq. (MHz)	Ins. Loss❖ 1dB (MHz)	Price $ea. (qty. 100)
TCM1-1	1C	1.5-500	5-350	.99
TCML1-11	1G	600-1100	700-1000	1.09
TCML1-19	1G	800-1900	900-1400	1.09
TCM2-1T	2A	3-300	3-300	1.09
TCM3-1T	3A	2-500	5-300	1.09
TTCM4-4	4B	0.5-400	5-100	1.29
TCM4-1W	4A	3-800	10-100	.99
TCM4-6T	4A	1.5-600	3-350	1.19
TCM4-14	4A	200-1400	800-1000	1.09
TCM4-19	4H	10-1900	30-700	1.09
TCM4-25	4H	500-2500	750-1200	1.09
TCM8-1	8A	2-500	10-100	.99
TCM9-1	9A	2-280	5-100	1.19

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Agile Synthesizers Add List-Mode Tuning

Versatility has been added to a line of fast-switching frequency synthesizers by means of a new list-mode frequency/phase/amplitude GPIB control option.

JACK BROWNE
Publisher/Editor

Fast-switching synthesizers serve a wide range of measurement applications, including evaluation of frequency-hopping systems (such as Bluetooth) and testing of components and systems, such as antennas, requiring many test points. The PTS series of frequency synthesizers from Programmed Test Sources (Littleton, MA) have long been known for their outstanding performance in terms of spec-tral purity and frequency agility when switching under binary-coded-decimal (BCD) remote control. They now add list-mode switching capability under GBIB command, greatly increasing their flexibility in automatic-test-equipment (ATE) systems requiring frequency-hopping or frequency-agile testing.

The PTS synthesizer line includes the PTS 3200 and PTS 6400 **(see figure)**. The former tunes from 1 to 3200 MHz while the latter operates from 1 to 6400 MHz. Both are based on high-speed direct-synthesis techniques that deliver frequency-switching speeds of only 20 µs—and now those switching speeds are available by means of either BCD or list-mode GPIB operation.

The 6.4-GHz PTS 6400 frequency synthesizer is now available with List-mode frequency/phase/amplitude switching.

Under standard GPIB operation, data-processing delays amount to about 5 ms switching speed for one of the synthesizers to settle to a new frequency after receipt of a GPIB control. But in the List mode of operation, a predefined list of frequency, amplitude, and phase settings is sequenced from internal memory and executed by the PTS frequency synthesizer with microsecond switching speed. For lists of as many as 128 settings of frequency, phase, and amplitude operating with an external trigger, the switching speed is basically the inherent switching speed of the synthesizer (about 20 µs).

For longer lists of as many as 2000 settings, the worst-case switching speed with an external trigger is 250 µs, including a 20-µs internal settling time. The list processing subsystem (available as an option) within each PTS frequency synthesizer allows operators to set the number of frequency points, the number of phase points, the number of output power levels, and the dwell time between switched points.

The List mode frequency/phase/amplitude switching capability is available on most PTS frequency synthesizers, a line that includes models ranging from the 0.1-to-40-MHz model PTS 040 to the 1-to-6400-MHz model PTS 6400. **Programmed Test Sources, Inc., 9 Beaver Brook Rd., P.O. Box 517, Littleton, MA 01460; (978) 486-3400, FAX: (978) 486-4495, e-mail: sales@programmedtest.com, Internet: www.programmedtest.com.**

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S2W2	S2W5	N2W5	2	±0.40
S3W2	S3W5	N3W5	3	±0.40
S4W2	S4W5	N4W5	4	±0.40
S5W2	S5W5	N5W5	5	±0.40
S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	±0.60
S8W2	S8W5	N8W5	8	±0.60
S9W2	S9W5	N9W5	9	±0.60
S10W2	S10W5	N10W5	10	±0.60
S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	±0.60
S30W2	S30W5	N30W5	30	±0.85
S40W2	S40W5	N40W5	40	±0.85

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Spatial Combining Leads To MM-Wave Power

This series of amplifiers employ transistor arrays and spatial-combining techniques to generate high output-power levels at millimeter-wave frequencies.

JACK BROWNE
Publisher/Editor

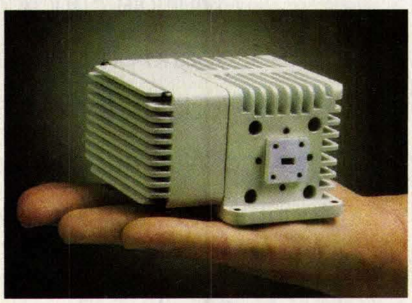
Millimeter-wave power usually suggests large vacuum tubes. The founders of Wavestream Corp. (West Covina, CA) have other thoughts on the topic, however, and now offer spatial-combining techniques in their grid-array amplifiers that promise to generate tube-like power at millimeter-wave frequencies from large arrays of high-frequency transistors. Among the company's first products is a single-chip amplifier capable of 4 W output power at 38 GHz with third-order intercept point of +44.5 dBm.

Wavestream's novel spatial-combining technology combines the output signals of individual transistor elements in free space, rather than in a conventional power combiner. By free-space combining, signal losses are almost negligible compared to a passive power combiner. With the spatial-combining approach employed in Wavestream's grid-array amplifiers, the effective number of amplifier elements is limited only by the number of transistors that can be fabricated on a given chip size.

Essentially, a grid-array amplifier is an integrated circuit (IC) with an array of amplifier elements or unit cells. An input antenna at each unit cell receives horizontally polarized input waves incident on the back of the IC. The input waveforms can be distributed across the IC by means of an inexpensive waveguide adapter. These waveforms are then amplified by the unit cells, and radiated from the face of the IC through an output antenna. Input and output sections are matched by means of on-chip passive elements. Output signals are collected and summed (in phase) in a waveguide port.

One of the first amplifiers produced with the technology was a single-chip, 38-GHz amplifier, using a low-voltage GaAs pseudomorphic high-electron-mobility-transistor (pHEMT) process **(see figure)**. The amplifier achieved +36 dBm (4 W) output power at 1-dB compression at 38 GHz. Gain varied from about 6 to 7 dB with an input-power range of +15 to +35 dBm, while AM/FM distortion was a low 2 deg./dB. The single-chip amplifier featured a third-order intercept point of +44.5 dBm.

Since matching structures are effectively moved off-chip, more of the GaAs chip area can be used for active elements (power), resulting in a lower cost per watt than other solid-state millimeter-wave amplifier approaches. The grid-array amplifiers employ free-space combining to reach efficiencies of 15 to 20 percent. **Wavestream Corp., 100 N. Barranca St., Suite 910, West Covina, CA 91791; (626) 331-1272, FAX: (626) 966-0193, www.wavestreamcorp.com.**



This prototype grid-array amplifier used a single pHEMT chip to generate +36 dBm output power at 1-dB compression at 38 GHz.

MEMS SPDT Switch Runs With +3 VDC

Designed for applications to 6 GHz, this MEMS SPDT switch handles peak RF power levels to 3 W and consumes less than 3 mW power.

JACK BROWNE
Publisher/Editor

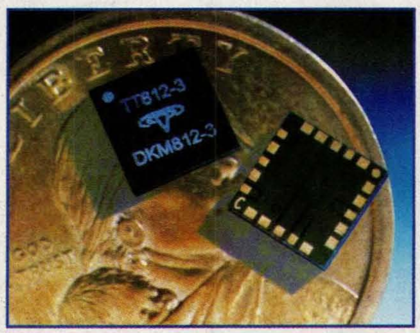
Microelectromechanical-systems (MEMS) technology has been commonly applied to RF components with moving parts, such as single-pole, double-throw (SPDT) switches, varactors, and inductors. Until now, low-voltage-actuated MEMS devices have been rare. With the introduction of the DKM812-3 RF switch from Dow-Key Microwave Corp. (Ventura, CA), however, 3 V is all that is needed to control this commercial MEMS reflective SPDT switch. With sufficiently low power consumption for portable applications, the SPDT MEMS switch is well suited for use through 6 GHz.

The MEMS SPDT switch consists of a moving part (a cantilever) that is shifted to different positions by a magnetic field. The magnetic field is manipulated by the applied control voltage. The technology has been in existence since the 1970s in the forms of temperature and pressure sensors, with accelerated development taking place in the 1990s thanks to funding from the Defense Advanced Research Projects Agency (DARPA). Since MEMS technology offers potential for tiny switches and other microwave components through about 50 GHz, both commercial and military developers have pushed the technology toward RF and optical applications.

The DKM812-3 RF switch **(see figure)** improves in efficiency and versatility over the company's earlier MEMS single-pole, single-throw switch (see *Microwaves & RF*, November 2001, p. 104). It can be used in a variety of applications, including automatic test equipment (ATE), wireless local-area networks (WLANs), Global Positioning System (GPS) receivers (Rxs), wireless handsets, and smart antennas. It features low insertion loss of typically 0.15 dB or less at 1 GHz and typically 0.3 dB or less at 6 GHz. The isolation is 30 dB at 1 GHz and more than 20 dB at 6 GHz, and the return loss is 14 dB or better from 100 kHz to 6 GHz. The tiny switch consumes less than 3 mW power.

The reflective RF switch handles average RF power of 2 W and as much as 3 W power on peaks. The device has been found to perform without compression at input power levels to +37 dBm at 2.4 GHz. The switch has an input third-order intercept point of +65 dBm minimum.

Although this device is specified for 10 million cycles, similar MEMS devices have been found to provide well over 100 million operations without degradation in performance. The MEMS switch, which is rated for operating temperatures of –40 to +85°C, is housed in a JEDEC MO-220 package that measures 7 × 7 × 1.5 mm. **Dow-Key Microwave Corp., 4822 McGrath St., Ventura, CA 93003-7718; (805) 650-0260, FAX: (805) 650-1734, Internet: www.dowkey.com.**



Model DKM812-3 is a +3-VDC RF MEMS switch with reasonable isolation and low insertion loss from DC to 6 GHz.

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Easy Radio USA, 110 Main St., Suite 1300 D, Saco, ME 04072-3500; (207) 286-1600, FAX: (207) 286-1700, e-mail: sales@easyradiousa.com, Internet: www.easyradiousa.com.

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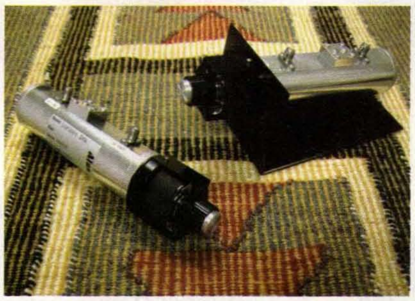

Alan Industries, Inc., P.O. Box 1203, Columbus, IN 47201; (800) 423-5190, (812) 372-5909, FAX: (812) 372-5909, e-mail: sales@alanindustries.com, Internet: www.alanindustries.com.

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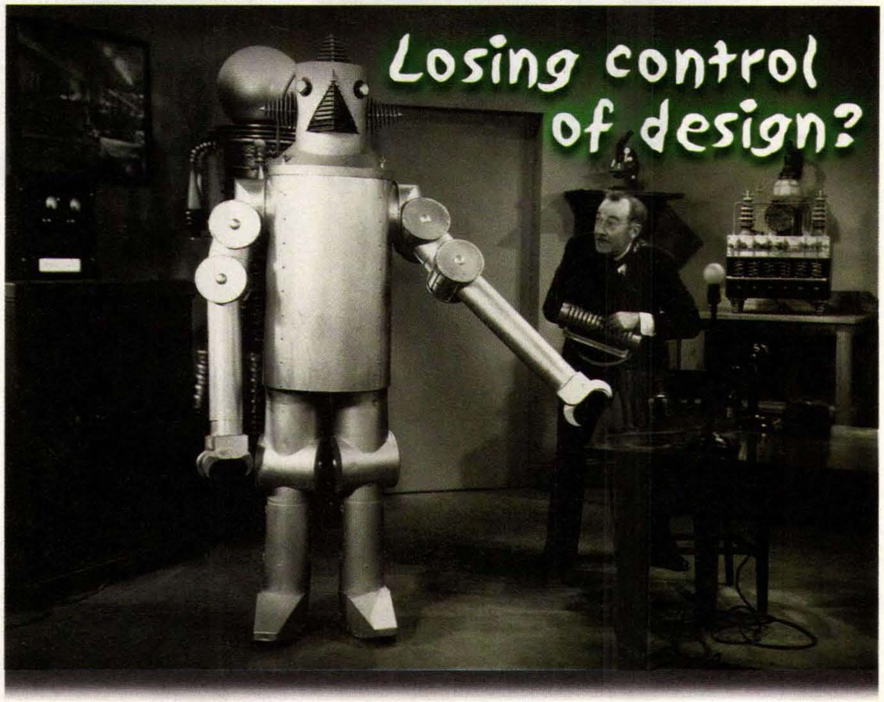

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10dB	DBTC-10-4-75	5-1000	1.4	20
12dB	DBTC-12-4	5-1000	0.7	21
13dB	DBTC-13-4	5-1000	0.7	18
13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
		1500-2000	1.1	14
18dB	DBTC-18-4-75	5-1000	0.8	21
20dB	DBTC-20-4	20-1000	0.4	21

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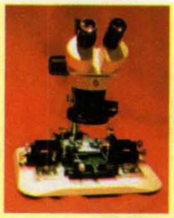

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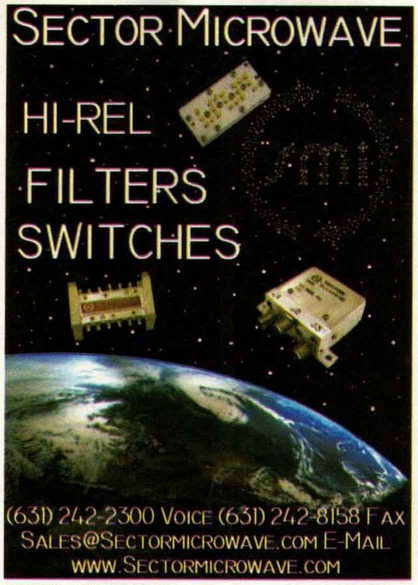

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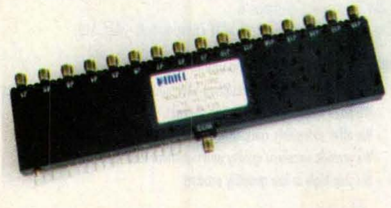

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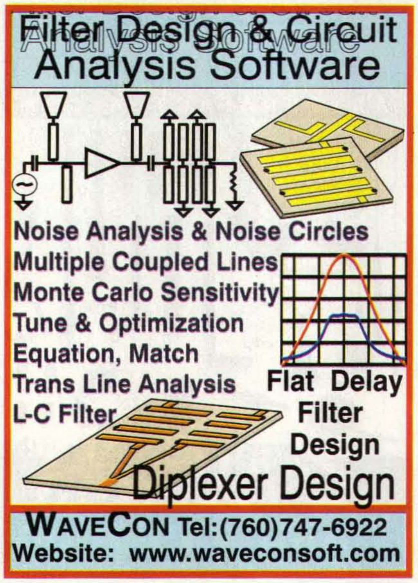

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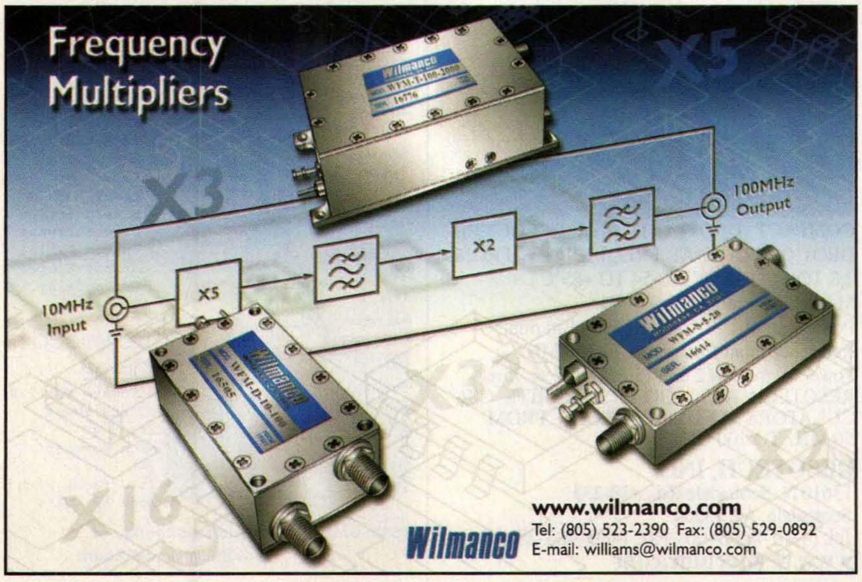

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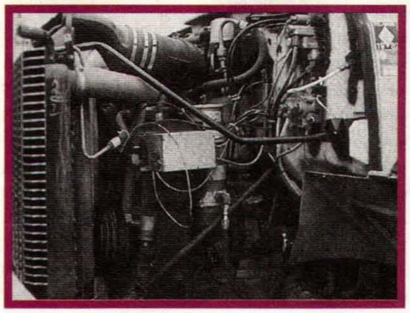
Penton TECHNOLOGY MEDIA

looking back



ALMOST 21 YEARS AGO, a news report examined the dream of Michigan inventor George Rashid of using radar technology to warn motor vehicles of potential collisions. The Gunn-diode-based system was designed to operate at X-band with a dish antenna.

next month

Microwaves & RF August Editorial Preview

Issue Theme: Wireless Applications

News

Ultrawideband (UWB) technology holds great promise as a low-cost method of short-range, broadband wireless communications. It is capable of data rates exceeding 100 Mb/s at low transmit powers and long battery life. Of course, as outlined recently in the first issue of the electronic newsletter Microwaves & RF UPDATE (available for free from www.PlanetEE.com), proponents of more traditional wireless applications, including Bluetooth, GPS, PCS, and WLANs, view UWB transmitters as potential interference sources. Still, companies such as XtremeSpectrum and Motorola have made major commitments to the technology, and firms such as Focus Enhancements believe that UWB technology may one day provide the means of short-range wireless video. What is UWB technology, and where is it going? Don't miss this Special News Report in August on the present and future of UWB technology.

Design Features

August Design Features will help engineers find solutions for their wireless designs. For example, an author from Nanjing, China will show how to design 2.4-GHz radio transmitters using a direct-modulation technique and optimized frequency-tripling method. Authors from Keithley will demonstrate how to improve wireless testing efficiency with the help of effective RF/microwave switching systems. An author from a leading software supplier will explain how a new simulation technique can be applied to the debugging of RF circuits and systems. Finally, an author from Paradigm Wireless Systems explores noise-mixing effects in high-power amplifiers (HPAs).

Product Technology

August provides a first look at an innovative silicon-based micro-resonator technology that represents an alternative to quartz crystal oscillators. These new sources offer the stability and noise performance of quartz oscillators, but at a fraction of the size. Also, August highlights a new line of fast-switching frequency synthesizers for applications through 40 GHz. Additional Product Features in August will highlight a line of synthesizers that blend fractional-N and direct-digital-synthesizer (DDS) technologies, as well as a family of path-fade simulators for checking signal propagation effects on microwave links, and a series of microwave training courses on CD-ROMs.